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A

DICTIONARY OF CHEMISTRY.

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A DICTIONARY
OF
CHEMISTRY
AND THE
ALLIED BRANCHES OF OTHER SCIENCES.

BY
HENRY WATTS, B.A., F.R.S., F.C.S.
EDITOR OF
'THE JOURNAL OF THE CHEMICAL SOCIETY.'

ASSISTED BY EMINENT CONTRIBUTORS.

VOL. I.
ABICHITE—CONGLOMERATE.

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PREFACE TO THE FIRST EDITION.

THIS WORK was originally intended as a New Edition of URE's *Dictionary of Chemistry and Mineralogy*; but the great changes made in chemical science since the publication of the last edition of that Dictionary (1831)—changes, not merely consisting in the addition of new discoveries, but involving a complete revolution in the mode of viewing and expressing chemical reactions—have rendered it almost impossible to adapt any matter written so long ago to the existing requirements of the science. The present must therefore be regarded as essentially a new work, in which only a few articles of URE's *Dictionary* are retained, chiefly of a descriptive character. In compiling it, the Editor has freely availed himself of the stores of information in GMELIN's "Handbook," GERHARDT's "Chimie Organique," ROSE's "Traité d'Analyse Chimique," DANA's "Mineralogy," RAMMELSBERG's "Mineralchemie," the "Handwörterbuch der Chemie," &c.; and has endeavoured, by careful consultation of original memoirs, to bring the treatment of each subject down to the present time. He has also been fortunate in obtaining the co-operation of several chemists of acknowledged ability and eminence, who have kindly contributed articles on subjects to which they have paid special attention:—a List of their names is given on the next leaf.

The work is essentially a Dictionary of Scientific Chemistry, and is intended as a Companion to the New Edition of URE's *Dictionary of Arts, Manufactures, and Mines*, to which therefore reference is, for the most part, made for the details of manufacturing operations; but those branches of chemical manufacture which have come into existence, or have received important developements, since the publication of that work, are described in this Dictionary as fully as its limits will allow, and in all cases explanations are given of the principles on which manufacturing processes are conducted, and the chemical changes which they involve. Particular attention has also been given to the description of processes of Analysis, both qualitative and quantitative.

In order that the work may, as far as possible, truly represent the present state of scientific chemistry, it has been found absolutely necessary to make the modern or "unitary" scale of atomic weights the basis of the system of notation and mode of exposition adopted. Especial care has, however, been taken that the treatment of all Articles which are likely to be consulted, for the sake of practical information, by manufacturers, or others not exclusively occupied in chemical pursuits, shall be such as to make them readily intelligible to all who possess a general knowledge of chemistry, though they may not have followed closely the recent developements of the theoretical parts of the science. Hence, in all such Articles (as ACETIC ACID, ANTIMONY, COPPER, &c.) the formulæ are given according to the old notation (printed for distinction, in *Italics*), as well as according to that adopted in the rest of the work.

Temperatures are given on the *centigrade* scale, excepting when the contrary is expressly stated.

HENRY WATTS.

LONDON: *July* 1863.

PREFACE TO THE SECOND EDITION.

IN the seven years which elapsed during the printing of the First Edition of this work, the views of chemists respecting the atomic weights of some of the elements underwent considerable change,—certain metals which, in Gerhardt's unitary system, were classed as monatomic, being subsequently regarded as diatomic, and their atomic weights doubled accordingly. As the work went on, it was found necessary to modify the formulæ in accordance with this change of view, and hence the formulæ in the different parts of the First Edition do not quite agree. In the present Edition the notation is rendered uniform throughout—the formulæ in the earlier volumes being altered in accordance with the views now generally received. The nature of this alteration will be understood by reference to the articles ATOMIC WEIGHTS and CLASSIFICATION in Vol. I.; METALS, ATOMIC WEIGHTS AND CLASSIFICATION OF, in Vol. III.; and the article ATOMICITY in the Supplemental Volume.

HENRY WATTS.

January 1872.

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*** Articles communicated by the several contributors are signed with their initials; articles taken from URE's *Dictionary of Chemistry* (fourth edition, 1831) are signed with the letter U; those which have no signature are by the Editor.

DICTIONARY OF CHEMISTRY.

A

ABICHITE. (*Aphanesite, Strahlerz, Strahlenkupfer.*) A native arsenate of copper, found chiefly associated with other copper ores and veins, in Cornwall and in the Hartz. The crystals belong to the monoclinic or oblique prismatic system, but they seldom exhibit any definite shape, being aggregated in radiating groups, or disposed, as extremely minute individuals, in cavities of quartz. Sp. gr. 4·2 to 4·4. Hardness, 2·5 to 3. Translucent or opaque, with vitreous lustre. Colour, blackish green inclining to blue. Streak, bluish-green. Dana (Mineralogy, ii. p. 428) gives for this mineral the formula $3CuO.AsO^5 + 3CuO.HO$,* or $Cu''^3(AsO^4)^2 + Cu^3H^2O^4$, deduced from the analyses of Rammelsberg and Damour. L. Gmelin (Handb. v. 471) gives the formula $5CuO.AsO^5 + 5HO$, deduced from the analysis of Chenevix, who found 54 per cent. of protoxide of copper, 30 per cent. of anhydrous arsenic acid, and 16 per cent. of water.

ABIETIC ACID. $C^{20}H^{30}O$? When Strasburg or Canadian turpentine (obtained respectively from *Abies picea* and *Abies balsamea*,) is distilled with water; the residue exhausted with absolute alcohol; the solution evaporated to dryness; the residual resin boiled with twice its weight of solution of carbonate of potassium; the alkaline liquid poured off; and the residue, which is a mixture of abietin and abietate of potassium, treated with 30 times its weight of water, — abietin separates in the crystalline form, while abietate of potassium remains in solution. This solution may be decomposed by sulphuric or hydrochloric acid, and the precipitated abietic acid purified by digestion in hot aqueous ammonia. As thus obtained, it is a resinous mass which dissolves easily in alcohol, ether and volatile oils, forming acid solutions, from which it separates in the crystalline state. At 55° it becomes soft and translucent. Its barium-salt is said to contain 191 parts of the acid to 76·6 parts (1 at.) of baryta. The acid is perhaps identical with sylvic or pymaric acid. (Caillot, J. Pharm. xvi. 436; Gerh. iii. 656.)

ABIETIN. Prepared as above. It is a tasteless inodorous resin, insoluble in water, soluble in alcohol, especially at the boiling heat, also in ether, rock-oil, and strong acetic acid, and separates in the crystalline form from these solutions by evaporation. It melts when heated, and solidifies in a crystalline mass on cooling. It is not acted upon by caustic potash. (Caillot.)

ABRAZITE. (*Gismondin.*) A mineral of the zeolite family, containing, according to Marignac's analysis:

$$4\left(\begin{matrix}CaO\\K^2O\end{matrix}\right\}2SiO^2) + 4Al^2O^3.SiO^2 + 18H^2O; \quad [Si = 28;\ O = 16].$$

$$\text{or } 2(CaO.KO).SiO^3 + 2(Al^2O^3.SiO^3) + 9HO; \quad [Si = 21;\ O = 8].$$

It is found on Vesuvius, at Aci-Castello in Sicily, and at Capo di Bove, near Rome. It occurs united with Phillipsite in quadratic octahedrons, generally aggregated in masses. Transparent or translucent, with greyish-white colour. Hardness = 4·5. Sp. gr. = 2·265. Gives off one-third of its water at 100°. Easily dissolves in acids and gelatinises. It was formerly supposed to be a variety of Phillipsite or lime-harmotome; but it differs from harmotome in composition as well as in crystalline form, the latter mineral crystallising in the dimetric system. (Dana, ii. 322.)

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* For the meaning of the italic formulæ, see PREFACE.

ABSINTHIN. $C^{16}H^{22}O^5$. The bitter principle of wormwood (*Artemisia absinthium*). It is prepared in the pure state, according to Luck, by exhausting the leaves of wormwood with alcohol, evaporating the extract to the consistence of a syrup, and agitating with ether. This ethereal solution is evaporated to dryness, and the residue treated with water containing a little ammonia, which dissolves the resin, and leaves the absinthin nearly pure. To complete the purification, it is digested with weak hydrochloric acid, washed with water, dissolved in alcohol, and treated with acetate of lead, as long as a precipitate is formed. After the removal of this precipitate by filtration, the excess of lead is precipitated by sulphuretted hydrogen, and the solution is evaporated. The absinthin then remains as a hard, confusedly crystalline mass, possessing an extremely bitter taste. It is but slightly soluble in water, very soluble in alcohol, and less so in ether. It possesses distinctly acid characters, and is dissolved by potash and ammonia. (Mein, Ann. Ch. Pharm. viii. 61; Luck, ibid. lxxviii. 87; Gerh. iv. 258.)

ABSORPTION OF GASES. See GASES.

ACACIN, or **ACACIA-GUM.** Known in commerce as *gum-arabic*. See ARABIN and GUM.

ACADIOLITE. A variety of chabasite from New Caledonia, distinguished by its large amount of alkali. (Hayes, Sill. Am. J. [2] I. 122.)

ACAJOU. The stem of the Acajou or Cashew-nut tree, *Anacardium occidentale*, yields a yellow gummy substance, sparingly soluble in water, which is a mixture of ordinary gum and bassorin. The pericarp of the nuts of the same tree contains a large quantity of a red-brown resinous substance, which produces inflammation and blistering of the skin. It may be extracted by ether, and the ethereal solution when slowly evaporated, leaves a residue consisting of a network of small crystals of anacardic acid, soaked in an oily liquid called cardol, to which the resin owes its acrid properties (Städeler, Ann. Ch. Pharm. lxiii. 137). The name acajou is also applied to a gum and resin obtained from the stem of the mahogany-tree. The gum resembles that of the cherry-tree.

ACAROID RESIN. The resin of *Xanthorrhea hastilis*, a liliaceous tree growing in New Holland; also called resin of Botany Bay. It has a yellow colour, an agreeable odour, and is soluble in alcohol, ether, and caustic potash. Its potash-solution treated with hydrochloric acid deposits benzoic and cinnamic acids. Nitric acid converts it into picric acid, and so readily, that this resin appears to be the best raw material for obtaining picric acid. By distillation, the resin yields a light neutral oil, which appears to be a mixture of benzol and cinnamol, and a heavy acid oil, consisting of hydrate of phenyl, mixed with small quantities of benzoic and cinnamic acids. (Stenhouse, Ann. Ch. Pharm. lvii. 84.)

ACECHLORIDE OF PLATINUM. See ACETONE, *Decompositions* (p. 29).

ACEDIAMINE. $C^2H^6N^2$. When hydrochlorate of acetamide is heated in a sealed tube to 180°—200°, and the product afterwards distilled, or when acetamide is distilled in a stream of dry hydrochloric acid gas, several volatile products pass over, and a residue is left consisting of hydrochlorate of acediamine, mixed with sal-ammoniac. (See ACETAMIDE):

$$\underbrace{2C^2H^5NO}_{\text{Acetamide.}} + HCl = \underbrace{C^2H^6N^2.\,HCl}_{\text{Hydrochlorate of acediamine.}} + \underbrace{C^2H^4O^2.}_{\text{Acetic acid.}}$$

Alcohol extracts the hydrochlorate of acediamine from this residue, and deposits it by spontaneous evaporation in prismatic crystals, which may be completely freed from adhering sal-ammoniac by solution in a mixture of alcohol and ether, and evaporation in vacuo. The hydrochlorate decomposed by sulphate of silver, yields the *sulphate of acediamine* $(C^2H^6N^2)^2.SO^4H^2$, which crystallises in colourless nacreous laminæ, easily soluble in water. The aqueous solution of the hydrochlorate mixed with dichloride of platinum yields the *chloroplatinate of acediamine*, $2(C^2H^6N^2.HCl).PtCl^4$, in rather large, hard, yellowish red prisms.

Acediamine is very unstable, and cannot be obtained in the free state. When the sulphate or hydrochlorate is heated with potash or baryta, ammonia is given off, and an acetate of the alkali is produced:

$$C^2H^6N^2 + 2H^2O = C^2H^4O^2 + 2NH^3.$$

Acediamine may be regarded as ammonia in which 1 at. H is replaced by the monatomic radical C^2H^4N (azethyl), its rational formula being then $N.H^2.C^2H^4N$ or as a double molecule of ammonia, N^2H^6, having 3 at. H replaced by the triatomic radical C^2H^3, making its formula $N^2.H^3.(C^2H^3)'''$ It bears the same relation to acetamide as ethylamine to alcohol:

$$C^2H^6O + NH^3 = C^2H^7N + H^2O: \text{ and } C^2H^5NO + NH^3 = C^2H^6N^2 + H^2O.$$

(Strecker, Ann. Pharm. ciii. 328.)

ACEPHOSGENIC ACID and **ACEPHOSSIC ACID.** Compounds produced by the action of phosphorus on acetone (see page 28).

ACETAL. $C^6H^{14}O^2$.—[Gm. ix. 38; Gerh. ii. 268.] A product of the oxidation of alcohol, first observed by Döbereiner, more fully examined by Liebig (Ann. Ch. Pharm. v. 25; xiv. 156), still further by Stas (Ann. Ch. Phys. [3] xix. 146), who first correctly determined its empirical formula, and finally by Wurtz (Compt. rend. xlviii. 478; Ann. Ch. Phys. [3] xlviii. 370; Ann. Ch. Pharm. cviii. 84). It is also obtained from aldehyde. (Wurtz and Frapolli, Ann. Ch. Pharm. cviii. 228.)

Preparation. I. From *Alcohol.* 1. By the imperfect oxidation of alcohol, under the influence of platinum-black. Pieces of pumice-stone previously washed and ignited are moistened with nearly absolute alcohol, and placed at the bottom of a large wide-necked flask, which is then filled up with capsules containing platinum-black, covered with a glass plate, and exposed to a temperature of 20°, till the whole of the alcohol is acidified. Alcohol of 60 per cent. is then poured into the flask, in quantity not quite sufficient to cover the pumice-stones, and the flask left to itself for two or three weeks in a room at a temperature of 20°, the glass plate being removed from time to time to admit fresh air. The thickish liquid is then drawn off, and the same process repeated with fresh alcohol, till several quarts of thickish acid liquid are obtained. This liquid is neutralised with carbonate of potassium, saturated with chloride of calcium and distilled, and the first fourth of the distillate is saturated with fused chloride of calcium, which separates from it a mixture of alcohol, acetic ether, aldehyde, and acetal. The aldehyde is removed by distillation over the water-bath; the residue treated with strong potash to decompose the acetic ether; the alcohol removed by washing with water; and the remaining liquid, the acetal, dried over chloride of calcium and rectified. (Stas.)

2. By distilling alcohol with dilute sulphuric acid and peroxide of manganese. A mixture of 2 parts alcohol, 3 parts peroxide of manganese, 3 parts sulphuric acid, and 2 parts water (the proportions given by Liebig for the preparation of aldehyde), is subjected to distillation as soon as the frothing which first ensues has ceased; 3 parts of liquid are distilled off; the distillate is rectified; and the portion which goes over at 80° is collected apart from that which distils between 80° and 95°. The first portion is mixed with chloride of calcium and rectified, the distillate obtained below 60° chiefly consisting of aldehyde, while above 60° a product is obtained, which, when treated with a strong solution of chloride of calcium, yields an ethereal liquid. The portion of the former liquid which came over between 80° and 95°, is also rectified, and the first portion of the resulting distillate treated with strong solution of chloride of calcium, whereupon it likewise yields an ethereal liquid. These ethereal liquids, containing aldehyde, acetic ether, &c. and acetal are united, and shaken with caustic potash to resinise the aldehyde and decompose the acetic ether. The brown liquid which floats upon the potash-solution is separated and distilled; the distillate again mixed with chloride of calcium; the liquid thus separated is heated to 100° for twenty-four hours with twice its volume of caustic potash in a sealed tube; the lower stratum is rectified; the distillate again shaken with chloride of calcium; and the separated liquid is digested with pulverised chloride of calcium, and submitted to simple rectification. Pure acetal then distils over from 100° to 105°. (Wurtz.)

3. By the action of chlorine upon alcohol, acetal being indeed the principal product of that reaction, so long as no substitution-products are formed:

$$3C^2H^6O + 2Cl = C^6H^{14}O^2 + 2HCl + H^2O.$$

Chlorine is passed through 80 per cent. alcohol cooled to between 10° and 15°, till a portion becomes turbid on the addition of water, indicating the formation of substitution-products. One fourth of the strongly acid liquid is then distilled off; the distillate neutralised with chalk; one fourth again distilled off; and the distillate, consisting of alcohol, acetic ether, aldehyde and acetal, treated as above to separate the acetal. (Stas.)

According to Lieben (Ann. Ch. Phys. [3] lii. 313), the chief products of the action of chlorine on alcohol of 80 per cent. are monochloracetal and dichloracetal. (p. 5.)

II. From *Aldehyde.* 1. By treating aldehyde with pentabromide of phosphorus, whereby it is converted into *bromide of ethylidene* $C^2H^4Br^2$ (a compound isomeric with bromide of ethylene), and acting on this compound with ethylate of sodium.

$$C^2H^4Br^2 + 2C^2H^5NaO = 2NaBr + 2C^6H^{14}O^2.$$

This mode of preparation is, however, very troublesome, on account of the difficulty of obtaining the bromide of ethylidene. Chloride of ethylidene $C^2H^4Cl^2$, (produced by the action of pentachloride of phosphorus on aldehyde) does not appear to yield acetal when treated with ethylate of sodium.

2. By passing hydrochloric acid gas into a mixture of 1 vol. aldehyde and 2 vols. absolute alcohol immersed in a freezing mixture, whereby the compound C^4H^9ClO is obtained in the form of an ethereal liquid floating on aqueous hydrochloric acid,—and treating this compound with ethylate of sodium:

$$C^2H^4O + C^2H^6O + HCl = C^4H^9ClO + H^2O$$
$$\text{and} \quad C^4H^9ClO + C^2H^5NaO = NaCl + C^6H^{14}O^2$$

(**Wurtz** and **Frapolli**, Compt. rend. xlvii. 418; Ann. Ch. Pharm. cviii. 223.)

Properties.—Pure acetal is a colourless liquid, less mobile than ether, having a peculiar agreeable odour and a refreshing taste, with an after-taste like that of hazel nuts. Sp. gr. 0·821 at 22·4. Boils at about 105° C., with the barometer at 0·768 met. Vapour density = 4·141.

It dissolves in eighteen times its volume of water at ordinary temperatures, the solubility increasing as the temperature rises. From the aqueous solution it is separated by chloride of calcium and other soluble salts. Ether and alcohol dissolve it in all proportions.

Decompositions.—1. Acetal is not altered by mere exposure to the air, but in contact with platinum-black it is quickly converted, first into aldehyde, and then into acetic acid:

$$\underbrace{C^6H^{14}O^2}_{\text{Acetal.}} + 2O = \underbrace{3C^2H^4O}_{\text{Aldehyde.}} + H^2O.$$

It is likewise oxidised by nitric and by chromic acid. 2. Caustic alkalies do not decompose it, if the air is excluded. 3. Chlorine abstracts hydrogen from it and forms substitution-products. 4. Strong sulphuric acid dissolves and then decomposes it, the mixture turning black. 5. Hydrochloric acid likewise dissolves and blackens it, forming choride of ethyl. 6. Pentachloride of phosphorus acts strongly upon it, forming a large quantity of chloride of ethyl, together with other products. 7. Heated in a sealed tube with several times its weight of glacial acetic acid, it yields acetic ether, more than 1 atom of that compound being formed from 1 atom of acetal.

These reactions tend to show that acetal is an ethyl-compound. Stas regarded it as a compound of 1 at. aldehyde with 1 at. ether:

$$C^2H^4O + C^4H^{10}O = C^6H^{14}O^2;$$

and Wurtz, in his earlier researches on glycol (Compt. rend. xliii. 478), regarded it as glycol $\left.\begin{matrix}C^2H^4\\H^2\end{matrix}\right\}O^2$, in which 2 at. hydrogen are replaced by ethyl $\left.\begin{matrix}C^2H^4\\(C^2H^5)^2\end{matrix}\right\}O^2$. This view of its constitution was corroborated by the result of distilling a mixture of alcohol and wood-spirit with sulphuric acid and peroxide of manganese, whereby a distillate was obtained consisting of *dimethylate of ethylene* $\left.\begin{matrix}C^2H^4\\(CH^3)^2\end{matrix}\right\}O^2$, and methylethylate of ethylene $\left.\begin{matrix}C^2H^4\\CH^3.C^2H^5\end{matrix}\right\}O^2$. Subsequent researches have however shown that acetal is not identical, but only isomeric with diethyl-glycol, or diethylate of ethylene $C^2H^4.(C^2H^5)^2.O^2$. For, when glycol $C^2H^4.H^2.O^2$ is treated with sodium, 1 at. hydrogen is eliminated, and the compound $C^2H^4.NaH.O^2$ is obtained. This compound treated with iodide of ethyl yields *ethylate of ethylene* $C^2H^4.C^2H^5.H.O^2$, whence, by the action of potassium, the compound $C^2H^4.C^2H^5.K.O^2$ is produced; and, lastly, this compound treated with iodide of ethyl yields *diethylate of ethylene* $C^2H^4.(C^2H^5)^2.O^2$. Now this liquid has a specific gravity of 0·7993 at 0° C., and boils at 123·5 C., whereas acetal has a sp. gr. of 0·821 at 22°·4, and boils at 105°, that is to say, 18°·5 lower. Recent experiments by **Beilstein** (Ann. Ch. Pharm. cxii. 240) seem to indicate that the rational formula of acetal is $C^4H^9O.C^2H^5.O$.

Chloracetals (A. **Lieben**, Ann. Ch. Phys. [3] lvi. 313). Three of these compounds have been obtained; viz. *mono-*, *di-*, and *tri-chloracetal*. The two former are produced by the action of chlorine on alcohol of ordinary strength (80 per cent.) When the chlorine has been passed through for some time, and the heavy oil which separates on addition of water is washed several times with aqueous chloride of calcium, and submitted to fractional distillation, it begins to boil at 80°, and the boiling point gradually rises to 200°, not, however, remaining stationary at any intermediate point. The portion which distils below 120° consists of aldehyde and compound ethers; that which distils above 120° (which is the larger portion) contains monochloracetal and dichloracetal. On again submitting it to fractional distillation, the greater part goes over between 170° and 185°; this portion consists chiefly of dichloracetal, which may be obtained pure by subsequent rectification. To separate the monochloracetal, the portion of the second distillate boiling below 170°, and the portion of the first distillate which passed over above 120°, are heated for several days with aqueous potash, whereby a watery liquid is obtained, containing chloride and formate of potassium, and an oily liquid consisting chiefly of monochloracetal mixed with dichloracetal; these compounds are finally separated by fractional distillation.

According to Lieben, the product of the action of chlorine on alcohol of ordinary strength does not contain acetal. This is contrary to the statement of Stas, who, in fact, prepared acetal by this very process. Probably the relative quantities of acetal, monochloracetal, and dichloracetal obtained depend on the duration of the action of the chlorine (compare page 3).

Monochloracetal, $C^6H^{12}ClO^2$, is a colourless liquid, having an ethereal aromatic odour, and boiling at about 155°. Vapour-density, by experiment 5·38; by calculation (2 vols.) 5·29. It is perfectly neutral, insoluble in water, soluble in alcohol. It is not attacked by aqueous potash, and does not precipitate nitrate of silver.

Dichloracetal, $C^6H^{12}Cl^2O^2$, is a colourless neutral aromatic liquid of sp. gr. 1·1383 at 14°. Boils at about 180°. Vapour-density, by experiment 6·45; by calculation (2 vols.) 6·435. (Lieben.)

Trichloracetal, $C^6H^{11}Cl^3O^2$, is produced, together with dichloracetal, by the action of chlorine on highly concentrated but not absolute alcohol. (Dumas, Lieben.)

ACETAMIDE. $C^2H^5NO = N.H^2.C^2H^3O$. Produced:

1. By heating acetate of ethyl with strong aqueous ammonia to about 120°:

$$\underbrace{C^2H^3O.C^2H^5.O}_{\text{Acetate of ethyl.}} + NH^3 = \underbrace{NH^2.C^2H^3O}_{\text{Acetamide.}} + \underbrace{C^2H^5.H.O}_{\text{Alcohol.}}$$

2. By the action of ammonia on acetic anhydride:

$$\underbrace{(C^2H^3O)^2O}_{\substack{\text{Acetic}\\ \text{anhydride.}}} + NH^3 = \underbrace{NH^2.C^2H^3O}_{\text{Acetamide.}} + \underbrace{C^2H^3O.H.O}_{\text{Acetic acid.}}$$

3. By distilling acetate of ammonium ($C^2H^4O^2.NH^3 = C^2H^5NO + H^2O$). A large quantity of ammonia is given off at first, then at 160° an acid distillate, consisting chiefly of acid acetate of ammonium; above 160°, a distillate containing acetamide which crystallises in the condensing tube; and above 190° nearly pure acetamide. By saturating glacial acetic acid with dry ammoniacal gas, and then distilling, ¼ of the acetic acid may be converted intc acetamide. (Kundig, Ann. Ch. Pharm. cv. 277.)

Acetamide is a white crystalline solid, which melts at 78° and boils at 221° or 222°. It deliquesces when exposed to the air, and dissolves readily in water. Heated either with acids or with alkalis, it takes up water, and is converted into acetic acid and ammonia.—Distilled with phosphoric anhydride, it gives up water and is converted into acetonitrile or cyanide of methyl C^2H^3N.—Heated in a stream of dry hydrochloric acid gas, it yields a liquid and a crystalline distillate, and a brownish non-volatile residue. The liquid portion of the distillate consists of strong acetic acid, together with small quantities of chloride of acetyl, and perhaps acetonitrile. The crystalline distillate is a mixture of hydrochlorate of acetamide, and a compound of acetamide and diacetamide $C^2H^5NO.C^4H^7NO^2$; the latter compound may be extracted by ether, in which the hydrochlorate of acetamide is insoluble. The non-volatile residue consists of hydrochlorate of acediamine mixed with sal-ammoniac. The decomposition is represented by the following equations:

$$2C^2H^5NO + HCl = \underbrace{C^4H^7NO^2}_{\text{Diacetamide.}} + NH^4Cl$$

$$2C^2H^5NO + HCl = \underbrace{C^2H^6N^2.HCl}_{\substack{\text{Hydrochlorate}\\ \text{of acediamine.}}} + \underbrace{C^2H^4O^2}_{\substack{\text{Acetic}\\ \text{acid.}}}$$

$$C^2H^5NO + 2HCl = \underbrace{C^2H^3OCl}_{\substack{\text{Chloride of}\\ \text{acetyl.}}} + NH^4Cl;\ C^2H^5NO - H^2O = \underbrace{C^2H^3N.}_{\text{Acetonitrile.}}$$

Acetamide acts both as a base and as an acid, combining with hydrochloric and with nitric acid, and likewise forming salts in which 1 atom of its hydrogen is replaced by a metal.

Hydrochlorate of Acetamide, $(C^2H^5NO)^2.HCl$ is prepared:—

1. By mixing acetamide fused at a gentle heat with oxychloride of phosphorus, dissolving the resulting crystalline mass in absolute alcohol, and leaving the solution to cool, or better, mixing it with ether; hydrochlorate of acetamide is then obtained in colourless crystalline needles. The crystalline mass first produced, appears to be a compound of acetamide and oxychloride of phosphorus, and this, on addition of alcohol, yields phosphate of ethyl and hydrochloric acid, which unites with the acetamide:

$$2C^2H^5NO + POCl^3 + 3(C^2H^5.H.O) = (C^2H^5NO)^2.HCl + P(C^2H^5)^3O^4 + 2HCl.$$

2. By directing a stream of dry hydrochloric acid gas on a solution of acetamide in alcohol and ether cooled from without, washing the resulting crystalline mass with anhydrous ether, and dissolving it in warm alcohol. The solution on cooling, or more quickly on addition of ether, deposits the hydrochlorate in crystals. This mode of preparation is preferable to the former. The compound forms long spear-shaped crystals, having an acid taste and reaction, easily soluble in water and alcohol, but insoluble in ether. Heated in a sealed tube to between 180° and 200°, it decomposes, yielding the same compounds that are obtained by heating acetamide in dry hydrochloric acid gas. (Strecker, Ann. Ch. Pharm. ciii. 321.)

Nitrate of Acetamide, $C^2H^5NO.NO^3H$, is obtained by dissolving acetamide in cold strong nitric acid. It forms colourless acid crystals, which melt at a moderate heat, and detonate at a higher temperature, leaving scarcely any residue.

CHLORACETAMIDES. — *Monochloracetamide*, $C^2H^4Cl.NO = N.H^2.C^2H^2ClO$, is obtained:

1. By the action of ammonia on monochloracetate of ethyl:

$$C^2H^2ClO.C^2H^5.O + NH^3 = N.H^2.C^2H^2ClO + C^2H^6O.$$

2. By bringing perfectly dry ammoniacal gas in contact with chloride of monochloracetyl:

$$C^2H^2ClO.Cl + 2NH^3 = N.H^2.C^2H^2ClO + NH^4Cl.$$

The product is a white amorphous mass, from which absolute alcohol extracts the amide, and deposits it in large shining laminæ. The amide dissolves in 10 parts of water and 10½ parts of alcohol at 24°, but is very sparingly soluble in ether. It is decomposed by potash, yielding chloride and acetate of potassium. (E. Willm. Ann. Ch. Phys. [3] xlix. 99.)

Trichloracetamide. $C^2H^2Cl^3NO = N.H^2.C^2Cl^3O$. This compound is produced by the action of gaseous or aqueous ammonia:

1. On chloride of trichloracetyl:

$$C^2Cl^3O.Cl + 2NH^3 = N.H^2.C^2Cl^3O + NH^4Cl.$$

2. On trichloracetate of ethyl:

$$C^2Cl^3O.C^2H^5.O + NH^3 = N.H^2.C^2Cl^3O + C^2H^6O.$$

3. On chloraldehyde, C^2Cl^4O, or the polymeric compound, perchloracetic ether, $C^4Cl^8O^2$:

$$C^2Cl^4O + 2NH^3 = C^2H^2Cl^3NO + NH^4Cl.$$

Also by the action of ammonia on the perchlorinated ethylic ethers of formic, carbonic, oxalic, and succinic acids, all these compounds yielding chloraldehyde when heated. The best product is obtained from perchloracetic ether. The mass is treated with cold water to dissolve the sal-ammoniac, and the residual trichloracetamide is crystallised from ether. It then forms snow-white crystalline laminæ. It dissolves also in boiling water and in alcohol, and crystallises from the aqueous solution in tabular crystals belonging to the rhombic system. It has a sweetish taste; melts at 135°, begins to turn brown at 200°, and boils at about 240°. It gives off ammonia when heated with potash. Ammonia dissolves it after a while, and the solution yields, by evaporation, beautiful prisms of trichloracetate of ammonium. Anhydrous phosphoric acid converts it into chloracetonitrile or cyanide of trichloromethyl: $C^2H^2Cl^3NO - H^2O = C^2Cl^3N$. (Cloez, Ann. Ch. Phys. [3] xvii. 305; Malaguti, ibid. xvi. 5; Cahours, ibid. xix. 352; Gerhardt, Compt. chim. 1848, 277; Traité, i. 760; Gm. ix. 270.)

Tetrachloracetamide, $C^2HCl^4NO = N.H.Cl.C^2Cl^3O$; sometimes called chloracetamic acid, is formed by exposing trichloracetamide, slightly moistened with water, to the action of chorine in sunshine. It then sublimes in needles, which may be purified by crystallisation from ether. It is permanent in the air, melts when heated, and partly sublimes undecomposed. It is nearly inodorous, but has a harsh disagreeable taste. Insoluble in water, but dissolves pretty readily in alcohol and wood-spirit, and very easily in ether. It dissolves without decomposition in cold aqueous alkalis, forming crystallisable salts. When boiled with potash, it gives off ammonia, and leaves chloride and carbonate of potassium:

$$C^2HCl^4NO + 3H^2O = NH^3 + 4HCl + 2\,CO^2.$$

(Cloez, Ann. Ch. Phys. [3] xvii. 305.)

Bromacetamides and *Iodacetamides* are likewise known.

Diacetamide, $C^4H^7NO^2 = NH(C^2H^3O)^2$. The ethereal solution of the compound of acetamide and diacetamide obtained by the action of hydrochloric acid gas on acetamide, deposits, when hydrochloric acid gas is passed through it, spicular crystals of hydrochlorate of acetamide, and the liquid filtered therefrom yields by evaporation over sulphuric acid, crystals of diacetamide, easily soluble in water, alcohol, and ether. The crystals when boiled with acids are resolved into acetic acid and ammonia, but not so readily as acetamide. The alcoholic solution boiled with dichloride of platinum deposits chloroplatinate of ammonium. (Strecker.)

Ethylacetamide. See Ethylamine.

Mercuracetamide, $C^4H^8Hg''N^2O^2$. An aqueous solution of acetamide saturated with mercuric oxide deposits by evaporation in vacuo, colourless crystalline crusts sparingly soluble in alcohol. *Silver-acetamide*, C^2H^4AgNO, is obtained in a similar manner in crystalline scales.

Phenylacetamide, or **Acetanilide**, see Phenylamine.

ACETENE. Synonyme of Ethylene and Olefiant Gas.

ACETIC ACID. *Essigsaure, Acide Acétique.* $C^2H^4O^2 = \left.\begin{matrix}C^2H^3O\\ H\end{matrix}\right\}O$, or $C^2H^3O^2.H.$ The hydrate or hydrated oxide of acetyl; it may be regarded as a molecule of water (H^2O), in which half the hydrogen is replaced by acetyl C^2H^3O. (It was formerly supposed to be derived from a radicle, C^4H^3, also called acetyl, which, in combination with 3 atoms of oxygen, formed anhydrous acetic acid $C^4H^3O^3$; and this in combination with an atom of water HO, formed hydrated acetic acid, $C^4H^3O^3.HO = C^4H^4O^4$] See Acetyl.

Sources.—Acetic acid exists, in nature, in the organic kingdom only, being found in the juices of many plants, especially of trees, and existing probably also in several of the animal secretions; but more commonly it results from the decomposition and oxidation of organic bodies.

Formation.—1. By the destructive distillation of organic substances, especially of wood.—2. By the action of oxidising agents, viz. atmospheric oxygen, chromic acid nitric acid, hypochlorous acid, &c., on alcohol and other organic bodies.—3. By the action of hydrate of potassium or hydrate of sodium at a high temperature on various organic bodies, *e.g.* succinic acid, oleic acid, malic acid, sugar, alcohol, &c.—4. By heating cyanide of methyl with aqueous caustic alkalis: $CH^3.CN + 2H^2O = C^2H^4O^2 + NH^3$.—5. By the action of carbonic anhydride on sodium-methyl; $CO^2 + CH^3Na = C^2H^3NaO^2$ (acetate of sodium).—6. By the reducing action of zinc or sodium-amalgam on chloracetic acid.

Preparation.—1. From *alcohol.* Alcohol is converted into acetic acid by various processes of oxidation; *e.g.* by the action of spongy platinum. If a tray of finely-divided spongy platinum be placed on a triangle over a porcelain dish containing a little alcohol gently warmed, and the whole covered with a bell-glass standing on a wedge, and open at the top so as to allow a gentle current of atmospheric air to pass through the apparatus, the oxidation of the alcohol proceeds rapidly, acetic acid condensing in abundance on the inside of the bell-jar.

By this process, however, much of the alcohol is converted into aldehyde, and lost by volatilisation. It would appear, in fact, that, in the formation of acetic acid by direct oxidation, aldehyde is always developed as an intermediate product, especially if the oxidising influence be not sufficiently rapid —

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + O = \underbrace{C^2H^4O}_{\text{Aldehyde.}} + H^2O;\ \text{and}\ \underbrace{C^2H^4O}_{\text{Aldehyde.}} + O = \underbrace{C^2H^4O^2}_{\text{Acetic acid.}}.$$

The oxidation of alcohol by atmospheric oxygen is greatly promoted by the presence of ferments; and, in fact, in the ordinary processes for making vinegar, an alcoholic solution is exposed to the joint influence of air and a ferment. In France and Germany wine is usually employed, and in England malt.

Wine Vinegar (*Weinessig, Vinaigre*).—The following is the plan of making vinegar practised in Paris. The wine destined for vinegar is mixed in a large tun with a quantity of wine-lees, and the whole being transferred into cloth-sacks, placed within a large iron-bound vat, the liquid matter is squeezed through the sacks by superincumbent pressure. What passes through is put into large casks set upright and having a small aperture at the top. In these it is exposed to the heat of the sun in summer, or to that of a stove in winter. Fermentation supervenes in a few days. If the heat should then rise too high, it is lowered by cool air and the addition of fresh wine. In the skilful regulation of the fermentative temperature consists the art of making good wine-vinegar. In summer, the process is generally completed in a fortnight; in winter, double the time is requisite. The most favourable temperature is between 25° and 30° (77° and 86° F.). The vinegar is then run off into barrels containing several chips of birch wood. In about a fortnight it is found to be clarified, and is then fit for the market. It must be kept in close casks.

At the same time that the alcohol is thus acidified, the nitrogenous organic matters which have served as ferments have likewise assumed new forms, and settled at the bottom of the vessel in the form of a white gelatinous mass, known as "mother of vinegar." This substance, which has been described by Mulder as a fungoïd plant, under the name of *Mycoderma Vini*, is a nitrogenised body, which has the power of exciting the acetification of pure alcohol in the presence of atmospheric air, probably in consequence of its own tendency to change. By treating it with potash, the whole of the nitrogen is removed, pure cellulose alone remaining.

A slight motion is found to favour the formation of vinegar, and to endanger its decomposition after it is made. Chaptal ascribes to agitation the operation of thunder, though it is well known, that when the atmosphere is highly electrified, beer is apt to become suddenly sour, without the concussion of a thunder-storm. Vinegar does not keep well in cellars exposed to the vibrations occasioned by the rattling of carriages. The lees, which had been deposited by means of isinglass during repose, are thus jumbled into the liquor, and promote the fermentation.

Almost all the vinegar of the north of France being prepared at Orleans, the manufacture of that place has acquired such celebrity as to render the process worthy of a separate consideration.

The Orleans casks contain nearly 400 pints of wine. Those which have been already used are preferred. They are placed in three rows, one over another, the upper ones having an aperture of two inches diameter, kept always open. The wine for acetification is kept in adjoining casks containing beech shavings, to which the lees adhere. The wine thus clarified is drawn off to make vinegar. One hundred pints of good vinegar, boiling hot, are first poured into each cask, and left there for eight days; ten pints of wine are mixed in, every eight days, till the vessels are full; and the vinegar is allowed to remain in this state fifteen days, before it is exposed for sale. The manufacturers at Orleans prefer wine of a year old for making vinegar; but if the wine has lost its extractive matter by age, it does not readily undergo the acetous fermentation.

The *used* casks, called *mothers*, are never emptied more than half, but are successively filled again, to acetify new portions of wine. In order to judge if the *mother* works, the vinegar makers plunge a spatula into the liquid; and according to the quantity of froth which the spatula shows, they add more or less wine. In summer, the atmospheric heat is sufficient. In winter, stoves heated to about 76° Fahr. maintain the requisite temperature in the manufactory.

Quick method of Vinegar-making (*Schnellessigbereitung*). Since the efficient conversion of the alcohol into acetic acid essentially depends upon the completeness of the oxidation, the German chemists have proposed to promote this result by enlarging the surface of the liquid exposed to the air. This is effected by allowing the alcoholic liquor to trickle down in a fine shower from a colander through a large oaken tub (called the vinegar generator, or graduator), filled with beech chips, up which a current of air ascends through apertures in the sides. By the oxidation which goes on, the temperature of the liquid rises to 37° or 40° C. (100 or 104° Fahr.). The liquid requires to be passed three or four times through the cask before the acetification is complete, which takes place in twenty-four or thirty-six hours. Care should be taken to allow a sufficient supply of air.

In England the same result is often attained by causing the alcoholic liquor to be distributed by means of a Barker's mill or other contrivance, over the beech shavings in a tun, whilst a current of air is forced up through it by two floating gasometers which are made to rise and fall alternately by steam power.

Wine vinegar is of two kinds, white or red, according as it is prepared from white or red wine. It contains, besides acetic acid and water, sugar, colouring matter, gum, and salts, especially bitartrate of potassium. Its specific gravity varies from 1·014 to 1·022.

MALT VINEGAR.—This is prepared from malt or a mixture of malt and raw barley, which is mashed with water as in the ordinary operation of brewing; the wort is then submitted to the vinous fermentation and the liquor thus obtained is converted by oxidation into vinegar. This is effected in two ways; either by the process of *fielding* or of *stoving*.

When *fielding*, that is, exposure to the open air, is resorted to, the wort must be made in the spring months, and then left to finish during several months of the warm season. In consequence, therefore, of the length of time required, the latter, or *stoving* process, is more generally used. The wash is introduced into barrels standing endways, tied over with a coarse cloth, and placed close together in darkened chambers, artificially heated by a stove. The liquor remains in these barrels until the acetification is complete. This usually occupies several weeks or months. The product is next introduced into large tuns with false bottoms, on which *rape* (the residuary fruit from the making of British wines) is placed, and allowed slowly to filter through them. Below the false bottom and above the true one is placed a tap which allows the vinegar to flow into a back or cistern. From this cistern a pump raises the liquid to the top of the vessel, and thence it flows through the rape to be again returned. Or sometimes the rape tuns are worked by pairs, one of them being quite filled with vinegar from the barrels, the other only three parts, so that the acetification is excited more readily in the latter than the former, and every day a portion of the vinegar is conveyed from one to the other, till the whole is finished and fit for sale.

Malt vinegar has a yellowish red colour, an agreeable acid taste, which is due to acetic acid; but the aromatic odour which distinguishes both it, and also wine vinegar, from pyroligneous acid (to be afterwards described) is imparted to it by the presence of acetic and other ethers.

Vinegar of four different strengths is sold by the makers, distinguished as Nos. 18, 20, 22, and 24. The last, which is the strongest, and is called proof vinegar, contains 5 per cent. of real acetic acid; its specific gravity is 1·019. (Pereira.)

Vinegar is liable to undergo a putrefactive decomposition, which was believed by the makers to be prevented by the addition of sulphuric acid, and they are allowed by law to add one-thousandth part by weight of sulphuric acid. It is now known that this is unnecessary; nevertheless the practice is still continued.

Distilled Vinegar.—By submitting wine or malt vinegar to distillation it is deprived of its colouring and other non-volatile matters, a colourless limpid liquid being obtained which is known in commerce as distilled vinegar. The product is, however, always weaker than the vinegar from which it has been derived, because the boiling point of strong acetic acid is above that of water; it is also liable to be contaminated with a small quantity of alcohol and empyreumatic bodies.

2. From *Wood*. Wood Vinegar, or Pyroligneous Acid.—The greater part of the acetic acid now employed in the arts is obtained by the destructive distillation of wood. The wood is heated in large iron cylinders like gas retorts, connected with a series of condensing vessels, the uncondensable gases which are evolved in large quantity being conveyed by pipes into the fire and aiding to maintain the heat. The liquid which condenses in the receivers consists of water, tar, wood-spirit or methylic alcohol, acetate of methyl, and acetic acid. The watery liquid, after being separated from the tar, is redistilled, the wood-spirit passing over among the first portions of the distillate, and the acetic or pyroligneous acid afterwards. The acid thus obtained is coloured, and has a strong tarry flavour, which cannot be removed by redistillation. To purify this crude acid, it is converted into acetate of sodium, either by direct saturation with carbonate of sodium, or more economically by saturating it with carbonate of calcium, and decomposing the calcium-salt with sulphate of sodium; and the acetate of sodium is purified from tarry matter, first by gentle torrefaction, and afterwards by recrystallisation. It is then decomposed by strong sulphuric acid diluted with half its weight of water, whereupon the sulphate of sodium, being insoluble in acetic acid, separates in the crystalline form, and may be separated by simple decantation; and the acetic acid thus separated is purified from the last traces of sulphate of sodium by distillation.

The process just described yields a very pure acid, but it is too expensive, principally in consequence of the large quantity of fuel which it requires. A more economical process has been proposed by Völckel (Ann. Ch. Pharm. lxxxii. 49; Chem. Soc. Qu. J. v. 274). In this process the crude wood-vinegar is immediately saturated with lime, without previous rectification. Part of the tarry matter then separates in combination with the lime, while the rest remains in solution with the acetate of calcium. The liquid, after being clarified by repose, or by filtration, is evaporated down to half its bulk in an iron pot, and mixed with a quantity of hydrochloric acid, sufficient to give it a slight acid reaction. The greater part of the tarry matter then separates, and may be skimmed off from the surface. The hydrochloric acid also decomposes certain compounds of the lime with creosote and other volatile substances, which are then expelled by heat; 33 gallons of crude wood-vinegar require for purification from 4 to 5 lbs. of hydrochloric acid. The acetate of calcium thus purified is completely dried and distilled with hydrochloric acid, 100 parts of the dry salt requiring from 90 to 95 parts of hydrochloric acid of sp. gr. 1·15 (or 20° Bm.). The sp. gr. of the acetic acid thus obtained is about 1·06 (8° Bm.). If it contains hydrochloric acid, it may be purified by redistillation, with addition of a small quantity of carbonate of sodium, or better 2 or 3 per cent. of bichromate of potassium, which, at the same time, destroys certain organic impurities that impart a peculiar odour to the acid.

The presence of hydrochloric or sulphuric acid in vinegar is easily detected by boiling the liquid for about twenty minutes with a small quantity of potato-starch, then leaving it to cool and adding a few drops of iodide of potassium. If the vinegar is pure, the blue colour of iodide of starch immediately makes its appearance, but not if sulphuric or hydrochloric acid is present, because these acids boiled with starch convert it into dextrin, which is not coloured blue by iodine (Payen). Sulphuric acid may also be detected by chloride of barium, and hydrochloric acid by nitrate of silver.

[For further details of the manufacture of acetic acid, see the fifth edition of *Ure's Dictionary of Arts, Manufactures and Mines*, vol. i. pp. 5 to 20.]

CRYSTALLISABLE OR GLACIAL ACETIC ACID.—This term is applied to the pure acid $C^2H^4O^2$, [or $C^4H^4O^4$] of sp. gr. 1·0635, because it is at ordinary temperatures a crystalline solid. The acid obtained by either of the processes above described consists of this compound more or less mixed with water. On distilling this dilute acid, a weaker acid passes over, and a stronger acid remains behind, because the boiling point of aqueous acetic acid increases with its concentration; and by repeated fractional distillation, an acid is at length obtained which crystallises at a low temperature. Crystallisable acetic acid is, however, more conveniently obtained by distilling certain acetates in the dry state with an equivalent quantity of concentrated sulphuric acid or disulphate of potassium; thus with acetate of potassium:

$$2C^2H^3KO^2 + SO^4H^2 = 2C^2H^4O^2 + SO^4K^2.$$

and:

$$C^2H^3KO^2 + SO^4HK = C^2H^4O^2 + SO^4K^2.$$

The proportions required are 98 pts. of dry acetate of potassium, or 82 acetate of sodium, or 79 acetate of calcium, or 163 acetate of lead, to 49 parts of monohydrated sulphuric acid, SO^4H^2, or 136 parts of disulphate of potassium, SO^4HK. Glacial acetic acid may also be conveniently obtained from diacetate of potassium, $C^2H^3KO^2.C^2H^4O^2$ by simple distillation. When neutral acetate of potassium is mixed with aqueous acetic acid, not too dilute, and distilled, part of the acetic acid unites with the neutral acetate, and a weaker acid passes over. But as the distillation goes on, the acid potassium-salt decomposes, the distillate becomes continually richer in acetic acid, and at length the pure crystallisable acid distils over. The temperature must not be allowed to exceed 300°; otherwise the acid suffers partial decomposition, and becomes coloured (Melsens, Compt. rend. xix. 611).—Crystallised acetate of copper also yields glacial acetic acid, when dried at a temperature between 160° and 180° and afterwards distilled at a higher temperature. Towards the end of the distillation the acid becomes mixed with acetone: that which passes over towards the middle must be redistilled to free it from copper mechanically carried over, probably in the form of cuprous acetate. The acid obtained by this process was formerly called *Spiritus Aeruginis* or *Spiritus Veneris*.

Properties.—Pure acetic acid solidifies at or below 15° C. in prismatic or tabular crystals. In closed vessels it remains liquid at 12°, and does not solidify till the vessel is opened and shaken. Its specific gravity in the solid state is 1·100 at 8·5 (Persoz). It melts at 16° (Lowitz), at or above 22°·5 (Mollerat), forming a thin colourless liquid of sp. gr. 1·063 (Mollerat); 1·065 at 13° (Persoz); 1·0635 at 15° (Mohr); 1·0622 (Sébille-Auger); 1·08005 reduced to 0° (Kopp, Pogg. Ann. lxxii. 1). It boils at 119° (Sébille-Auger); at 117°·3 (Kopp). The density of its vapour is different at different temperatures, compared with an equal bulk of air at the same temperature. At temperatures considerably above the boiling point, it follows the ordinary law of condensation to 2 volumes; thus at 300° and upwards the sp. gr. of the vapour is found by Cahours to be 2·00, which agrees almost exactly with the calculated density, supposing the molecule to occupy 2 volumes. For the atomic weight of acetic acid, compared with hydrogen as unity is 60 ($= 2C + 4H + 2O = 24 + 4 + 32$); and if this be the weight of 2 volumes of the vapour, it follows that the weight of 1 volume of vapour, or in other words, the specific gravity as compared with hydrogen, will be 30; and multiplying this number by 0·0693, the sp. gr. of hydrogen referred to air as unity, we obtain for the sp. gr. of acetic acid vapour referred to air as unity, the number 2·079.

But at temperatures near the boiling point, the density of the vapour is much greater, exhibiting a condensation to $\frac{4}{3}$-volume, or even less. The following table exhibits the density of the vapour at various temperatures as determined by Cahours (Compt. rend. xix. 771; xx. 51):

Temperature.	125°	130°	140°	150°	160°	170°	190°	200°	230°	250°	300°
Density.	3·20	3·12	2·90	2·75	2·48	2·42	2·30	2·22	2·17	2·09	2·08

The tension of the vapour is 7 mm. at 15°; 14·5 mm. at 22°, and 32 mm. at 32°. (Bineau, Ann. Ch. Phys. [3] xviii. 226.)

The acid has a pungent sour taste and odour, blisters the skin, and acts as an acrid poison. It does not redden litmus paper *per se*, but very strongly when mixed with water.

Decompositions.—1. The vapour of acetic acid is inflammable, and burns with a blue flame, producing water and carbonic acid. When it is passed through a red-hot tube, the greater part remains unaltered, but a portion is decomposed, yielding free carbon and combustible gases, together with acetone, napthalin, hydrate of phenyl and benzol. (Berthelot, Ann. Ch. Phys. [3] xxxiii. 295.)

2. A mixture of glacial acetic and strong *sulphuric acid* blackens when heated, giving off carbonic and sulphurous anhydrides. *Fuming sulphuric acid* mixes with glacial acetic acid without evolution of gas; but the mixture becomes hot, and if it be raised to a higher temperature, carbonic anhydride is given off, mixed with only a small quantity of sulphurous anhydride. *Sulphuric anhydride* dissolves in acetic acid without evolution of gas, and on heating the mixture, sulphacetic acid is produced.

3. Acetic acid is not sensibly attacked by *nitric acid.*

4. *Periodic acid* converts it into carbonic or formic acid, with formation of iodic acid and separation of iodine.

5. *Chlorine* in sunshine converts acetic acid into monochloracetic and trichloracetic acids, the quantity of the one or the other being greater, according as the acetic acid or the chlorine is in excess. See CHLORACETIC ACID.

6. Glacial acetic acid heated with *bromine* in a sealed tube forms bromacetic and dibromacetic acids. *Iodine* has no action on acetic acid even in sunshine.

7. With *pentachloride of phosphorus*, glacial acetic acid forms hydrochloric acid, chloride of acetyl and oxychloride of phosphorus:

$$C^2H^3O.H.O + PCl^3.Cl^2 = C^2H^3O.Cl + HCl + PO.Cl^3.$$

8. With *pentasulphide of phosphorus*, it forms thiacetic acid and phosphoric anhydride:

$$5(C^2H^3O.H.O) + P^2S^5 = P^2O^5 + 5(C^2H^3O.H.S).$$

The difference between the mode of action of the pentachloride and pentasulphide of phosphorus, the former giving rise to two distinct chlorine-compounds, $C^2H^3O.Cl$ and HCl, whereas the latter forms only one sulphur-compound, is very remarkable, and shows clearly the propriety of regarding chlorine as a monatomic, and sulphur as a diatomic radicle.

AQUEOUS ACETIC ACID.—Acetic acid mixes with water in all proportions, imparting to it its taste and smell. The density of the aqueous acid varies with its strength in a remarkable manner. When water is gradually added to glacial acetic acid, the density increases till a hydrate is formed containing 79 pts. of crystallised acid to 21 water, and having the composition $C^2H^4O^2.\ H^2O$. This hydrated acid has a density of 1·073 and boils at 104°. All further additions of water diminish the density of the acid.

The following table constructed by Mohr (Ann. Ch. Pharm. xxxi. 277) gives the quantity of crystallisable acetic acid in 100 pts. of the aqueous acid of different densities.

Perc.	Sp. Gr.	Perc.	Sp. Gr.	Perc.	Sp. Gr	Perc.	Sp. Gr.	Perc.	Sp. Gr.
100	1·0635	80	1·0735	60	1·067	40	1·051	20	1·027
99	1·0655	79	1·0735	59	1·066	39	1·050	19	1·026
98	1·0670	78	1·0732	58	1·066	38	1·049	18	1·025
97	1·0680	77	1·0732	57	1·065	37	1·048	17	1·024
96	1·0690	76	1·0730	56	1·064	36	1·047	16	1·023
95	1·0700	75	1·0720	55	1·064	35	1·046	15	1·022
94	1·0706	74	1·0720	54	1·063	34	1·045	14	1·020
93	1·0708	73	1·0720	53	1·063	33	1·044	13	1·018
92	1·0716	72	1·0710	52	1·062	32	1·042	12	1·017
91	1·0721	71	1·0710	51	1·061	31	1·041	11	1·016
90	1·0730	70	1·0700	50	1·060	30	1·040	10	1·015
89	1·0730	69	1·0700	49	1·059	29	1·039	9	1·013
88	1·0730	68	1·0700	48	1·058	28	1·038	8	1·012
87	1·0730	67	1·0690	47	1·056	27	1·036	7	1·010
86	1·0730	66	1·0690	46	1·055	26	1·035	6	1·008
85	1·0730	65	1·0680	45	1·055	25	1·034	5	1·007
84	1·0730	64	1·0680	44	1·054	24	1·033	4	1·005
83	1·0730	63	1·0680	43	1·053	23	1·032	3	1·004
82	1·0730	62	1·0670	42	1·052	22	1·031	2	1·002
81	1·0732	61	1·0670	41	1·051	21	1·029	1	1·001

Mollerat, Ann. Chim. lxviii. 88, and **Ad. van Toorn** (J. pr. Chem. vi. 171) have also given tables of the specific gravities of acetic acid of different degrees of concentration.

It will be seen from the preceding table that the specific gravity of acetic acid varies but slowly, a difference of 1 per cent. corresponding to a difference of only ·001 in the density, and sometimes even less. For this reason, the determination of the strength of commercial acetic acid by the hydrometer or *acetometer*, as it is called when graduated for this purpose, is not much to be depended on. The presence of colouring matter, saline substances and other impurities, which frequently occur in vinegar, are of course an additional source of inaccuracy in this method of estimation. It is better, therefore, to determine the strength of the acid by ascertaining the quantity of a standard solution of caustic soda or ammonia, required to neutralise a given volume. (See ACIDIMETRY and ANALYSIS, VOLUMETRIC.) This method, when applied to acetic acid, is affected with a slight source of inaccuracy, arising from the fact that the normal or neutral acetates of the alkalis exhibit a slight alkaline reaction. The error thence arising is, however, of small amount, not exceeding $\frac{1}{10}$ per cent. for an acid containing 10 per cent. of crystallisable acetic acid, as shown by **Otto** (Ann. Ch. Pharm. cii. 69). Moreover, it may be completely obviated by using a solution of caustic soda, graduated for the purpose by means of a solution of pure acetic acid of known strength (ANALYSIS, VOLUMETRIC). **Greville Williams** (Pharm. J. Trans. xiii. 594) recommends for the volumetric estimation of acetic acid a graduated solution of lime in sugar-water.

Acetic acid mixes in all proportions with alcohol. It dissolves resins, gum-resins, camphor, and essential oils. Its use for culinary purposes is well known. Its odour is employed in medicine to relieve nervous head-ache, fainting fits, or sickness occasioned by crowded rooms. Pungent smelling salts consist of sulphate of potassium moistened with glacial acetic acid. Pyroligneous acid is largely used in calico-printing; the tar and empyreumatic substances present in it appear to be rather advantageous than otherwise for that purpose. Large quantities of acetic acid are also used for the preparation of the acetates of lead, copper, aluminium, &c. (See *Dictionary of Arts, Manufactures, and Mines.*)

Acetates.—Acetic acid is monobasic, the general formula of its normal salts being $C^2H^3O^2.M$ or generally $(C^2H^3O^2)^n.M^{(n)}$, the symbol $M^{(n)}$ denoting a metal whose atomicity is *n*. It also forms basic salts, which may be regarded as compounds of the normal acetates with oxides. The normal acetates all dissolve in water, and most of them readily. The least soluble are the silver and mercury salts, so that solutions of other acetates added to mercurous nitrate or nitrate of silver, throw down white shining scales of mercurous acetate or silver-acetate; but generally speaking, acetates are not formed by precipitation: they are produced by the action of acetic acid on metallic oxides or carbonates; many carbonates, however, the barium and calcium salts, for example, are not decomposed by acetic acid in its most concentrated state.

All acetates are decomposed by heat, most of them yielding carbonic anhydride, acetone and an empyreumatic oil. Those which are easily decomposed, and likewise contain bases forming stable carbonates, are almost wholly resolved into acetone and a carbonate of the base; this is especially the case with acetate of barium:

$$(C^2H^3O^2)^2Ba'' = C^3H^6O + CO^3Ba''.$$

Those which, like the potassium and sodium salts, require a higher temperature to decompose them, yield more complex products, but always a certain quantity of acetone. Among the products are found certain homologues of acetone, viz. *methylacetone* $C^3H^5(CH^3)O$ and *ethylacetone* $C^3H^5(C^2H^5)O$, together with *dumasin* $C^6H^{10}O$. (**Fittig**, Ann. Ch. Pharm. cx. 17). Acetates containing weaker bases, give off part of the acetic acid undecomposed, the remaining portion being resolved into acetone and carbonic anhydride, or if the heat be strong, yielding empyreumatic oil and charcoal: the residue consists sometimes of oxide, sometimes, as in the case of copper and silver, of reduced metal; in this case part of the acetic acid is burnt by the oxygen abstracted from the metal. Acetates heated with a large excess of fixed caustic alkali, are resolved at a temperature below redness into marsh gas and alkaline carbonate, *e. g.*:

$$C^2H^3KO^2 + KHO = CH^4 + CO^3K^2.$$

Acetates distilled with sulphuric acid, give off the odour of acetic acid, and yield a distillate which dissolves oxide of lead, and acquires thereby an alkaline reaction. Distilled with sulphuric and alcohol, they yield acetate of ethyl, recognisable by its odour. The neutral acetates impart to solutions of ferric salts a reddish yellow or red-brown colour, according to the degree of dilution. Acetates heated to redness with arsenious acid give off the odour of cacodyl. The acetates of the alkali-metals, and probably others also, treated with oxychloride of phosphorus, yield chloride of acetyl, together with a tribasic phosphate:

$$3(C^2H^3O.Na.O) + PO.Cl^3 = 3C^2H^3OCl + PO^4Na^3.$$

ACETATES OF ALUMINIUM.—α. *Triacetate.* Aluminium being regarded as trivalent ($Al^2 = H^6$ or $Al = H^3$) the normal salt should be a triacetate $(C^2H^3O^2)^3Al$ or $(C^2H^3O^2)^6.Al^2$ [or $Al^2O^3.3C^4H^6O^3$, regarding it as a compound of alumina with anhydrous acetic acid]. This salt, however, exists only in solution, and is decomposed by evaporation. The solution is obtained by digesting recently precipitated trihydrate of aluminium in strong acetic acid, or by precipitating a solution of the trisulphate with acetate of lead:

$$(SO^4)^3Al^2 + 3(C^2H^3O^2)Pb = 3SO^4Pb + (C^2H^3O^2)^6Al^2.$$

This salt is largely used as a mordant in dyeing and calico-printing, and is generally prepared for this purpose by precipitating alum with acetate of lead. The solution thus formed contains sulphate of potassium as well as acetate of aluminium.

β. *Diacetate.* When the solution of the triacetate obtained by decomposing trisulphate of aluminium with acetate of lead is evaporated at a low temperature, with sufficient rapidity, as by spreading the concentrated liquid very thinly on plates of glass or porcelain, exposing it to a temperature not exceeding 100° F. (37°·7 C.), and, as it runs together in drops, rubbing it constantly with a spatula, *diacetate of aluminium* remains in the form of a dry powder containing $\left.\begin{matrix}(C^2H^3O)^2\\(Al^2)^{vi}\end{matrix}\right\}O^4 + 5H^2O$ [or $2C^4H^6O^3.Al^2O^3 + 5H^2O$]. The diacetate thus obtained dissolves easily and completely in water, and the solution when heated deposits dihydrate of aluminium soluble in water. (See ALUMINIUM.) But when the solution, instead of being quickly evaporated, is left to itself in the cold for some days, it deposits a white saline crust, which is an *allotropic diacetate of aluminium insoluble in water.* Heat effects the same change more rapidly, and the insoluble diacetate then separates in the form of a granular powder. At the boiling temperature, the liquid is thus deprived in half an hour of the whole of its alumina, which goes down with $\frac{2}{3}$ of the acetic acid, leaving $\frac{1}{3}$ in the liquid. The insoluble diacetate digested in a large quantity of water is gradually changed into the soluble modification, part of which is, however, decomposed during the process into acetic acid and the soluble dihydrate. (Walter Crum, Chem. Soc. Qu. J. vi. 217.)

ACETATES OF AMMONIUM.—α. *Normal acetate.* $C^2H^3O^2.NH^4$. A white odourless salt, obtained by saturating glacial acetic acid with dry ammonia. It is very difficult to obtain in the crystalline form: for its aqueous solution loses ammonia on evaporation, and is converted into the acid salt (β). It is readily soluble in water and alcohol. Its aqueous solution, known in the Pharmacopeia as *Spiritus Mindereri*, is prepared by saturating aqueous acetic acid with ammonia or carbonate of ammonium. This solution is transparent and colourless, with a peculiar odour and cooling pungent taste. When kept it is decomposed, and becomes alkaline, owing to the formation of carbonate of ammonium; by heat it is converted into a solution of the acid salt (β).

β. *Acid Acetate,* $C^2H^3O^2.NH^4.C^2H^4O^2$ or $C^4H^6O^3.(NH^4)^2O + C^4H^6O^3.H^2O$. Obtained as a white crystalline sublimate when dry powdered chloride of ammonium is heated with an equal weight of acetate of potassium or calcium, ammonia being given off simultaneously. A warm saturated solution of this salt kept in a closed bottle deposits long needle-shaped crystals. This salt is also obtained in a radiated crystalline mass, by evaporating the aqueous solution of the normal salt (α). The crystals redden litmus and deliquesce rapidly in the air. They melt at 76° C. and sublime undecomposed at 121°. The composition of this salt is probably that expressed by the above formula.

ACETATE OF BARIUM, $(C^2H^3O^2)^2Ba''$.—Prepared by decomposing carbonate or sulphide of barium with acetic acid. The solution evaporated at a gentle heat yields flattened prisms containing $(C^2H^3O^2)^2Ba'' + H^2O$, but when cooled to 0° C. it yields rhomboidal prisms, isomorphous with acetate of lead, and containing $(C^2H^3O^2)^2Ba'' + 3H^2O$. The crystals dried at 0° yield the anhydrous salt in the form of a white powder, which, when strongly heated, is resolved into acetone and carbonate of barium.

ACETATE OF BISMUTH separates in micaceous laminæ from a warm mixture of nitrate of bismuth and acetate of potassium. Acetic acid mixed with a solution of nitrate of bismuth prevents the precipitation of a basic salt of that metal by water.

ACETATE OF CADMIUM.—Small prismatic crystals very soluble in water (Stromeyer). According to Meissner and John, it is not crystallisable, but forms a gelatinous mass.

ACETATE OF CALCIUM, $(C^2H^3O^2)^2Ca''$, crystallises in prismatic needles, which effloresce in the air, and dissolve in water and in alcohol. The salt is decomposed by heat into acetone and carbonate of calcium. A solution of acetate and chloride of calcium in equivalent proportions yields, by slow evaporation, large crystals containing $(C^2H^3O^2)^2Ca''.Ca''Cl^2 + 10H^2O$.

ACETATE OF CERIUM.—Small needles sparingly soluble in alcohol.

ACETATES OF CHROMIUM.—The *chromous salt*, $(C^2H^3O^2)^2Cr'' + H^2O$, is produced by pouring protochloride of chromium into a solution of acetate of potassium or sodium. It forms red transparent crystals, which when moist absorb oxygen very rapidly from the air, undergoing a true combustion. The *chromic* salt is obtained as a green crystalline crust, very soluble in water, by dissolving chromic hydrate in acetic acid: the solution scarcely reddens litmus.

ACETATES OF COBALT.—The red liquid formed by dissolving carbonate of cobalt in acetic acid, yields by evaporation a red residue which turns blue when heated. It may be used as a sympathetic ink. The oxides Co^2O^3 and Co^3O^4 also dissolve in acetic acid without separation of oxygen, forming brown solutions. The solution of the sesquioxide sustains a boiling heat without decomposition.

ACETATES OF COPPER.—*a. Cuprous Acetate*, $(C^2H^3O^2)^2(Cu^2)''$. This salt sublimes towards the end of the distillation of normal cupric acetate. According to Berzelius, it is contained in common green verdigris, and sublimes when that substance is distilled. It forms soft, loose, white flakes, which redden litmus and have a caustic astringent taste. Water decomposes it into normal cupric acetate and yellow cuprous hydrate.

b. Cupric Acetates.—(Berzelius, Pogg. Ann. ii. 233; Traité, iv. 173; Gm. viii. 323; Gerh. i. 728.) Four of these salts are known, viz.:—

Normal Cupric Acctate .	$(C^2H^3O^2)^2Cu''$	=	$C^4H^6O^3 . Cu''O$.
Sesquibasic . . .	$2(C^2H^3O^2)^2Cu'' . Cu''O$	=	$2C^4H^6O^3 . 3Cu''O$.
Bibasic	$(C^2H^3O^2)^2Cu'' . Cu''O$	=	$C^4H^6O^3 . 2Cu''O$.
Tribasic	$(C^2H^3O^2)^2Cu'' . 2Cu''O$	=	$C^4H^6O^3 . 3Cu''O$.

1. The normal salt $(C^2H^3O^2)^2Cu''$, called also *Crystallised Verdigris, Verdet, Cristaux de Venus*, is produced by dissolving cupric oxide or common verdigris in acetic acid, or by precipitating a solution of normal acetate of lead with sulphate of copper: in either case, the liquid must be highly concentrated and then left in a cool place. It forms dark bluish-green prisms belonging to the monoclinic system, and containing $(C^2H^3O^2)^2Cu'' + H^2O$. The ordinary combination is $\infty P . 0P . +P . +2P\infty$. Twin-crystals also occur. Ratio of the axes: $a : b : c = 0·6473 \; 1 : 0·5275$. Inclination of the axes = 63°. Inclination of the faces, $\infty P : \infty P$ in the plane of the orthodiagonal and the principal axis = 108°; $\infty P : 0P = 105° \; 30'$; $0P : +2P\infty = 119° \; 4'$. Cleavage parallel to $0P$ and ∞P. The salt is efflorescent, soluble in water, sparingly soluble in alcohol, and poisonous like all soluble copper-salts. The crystals after drying in vacuo at ordinary temperatures, suffer no further diminution in weight at 100°, but give off 9·6 per cent. of water between 110° and 140°, then nothing more below 240°; between 240° and 260° strong acetic acid, which when rectified yields 32 per cent. of the crystallisable acid; at 270° white fumes which condense into white flakes of cuprous acetate; and lastly a mixture of carbonic anhydride and a combustible gas. At 330° the decomposition is complete, and a reddish substance remains consisting chiefly of metallic copper. The solution boiled with sugar yields a red precipitate of cuprous oxide. Acetate of copper crystallised at a temperature near 8°, yields crystals containing $(C^2H^3O^2)^2Cu'' + 5H^2O$.

2. The basic cupric acetates are contained in *common verdigris* (*vert-de-gris, Grünspan*), a substance obtained by exposing plates of copper to the air in contact with acetic acid, and much used as a pigment and as a mordant in dyeing wool black. There are two varieties of this substance, the blue and the green, the former consisting almost wholly of dibasic cupric acetate, the latter of the sesquibasic salt mixed with smaller quantities of the dibasic and tribasic acetates. The *bibasic salt* or *blue verdigris* is prepared at Montpellier and in other parts of the south of France, by exposing copper to the air in contact with fermenting wine-lees. The wine-lees are loosely packed in casks together with straw, till they pass into the state of acetous fermentation; and when that is ended, they are arranged in pots covered with straw, in alternate layers with rectangular plates of copper, which when used for the first time, are previously moistened with a cloth dipped in a solution of normal acetate of copper, and then dried. At the end of three weeks, the plates are taken out; placed in an upright position to dry; dipped six or eight times in water in the course of as many weeks; and again left to dry, during which operations the verdigris continually swells up. It is then scraped off, the plates again arranged alternately with sour wine-lees, and the same processes are repeated till the plates are quite corroded. The same compound is obtained by exposing copper plates to damp air in contact with normal acetate of copper made into a paste with water. It forms delicate, silky, blue, crystalline needles and scales, which yield a beautiful blue powder. They contain 6 at. water, which they give off at 60°, and are then converted into a green mixture of the monobasic and tribasic salt:—

$$2(C^2H^3O^2)^2Cu.CuO = (C^2H^3O^2)^2Cu + (C^2H^3O^2)^2Cu.CuO.$$

By repeated exhaustion with water, it is resolved into the insoluble tribasic salt, and a solution of the normal and sesquibasic salts:

$$5(C^4H^6O^3.2CuO) = 2(C^4H^6O^3.3CuO) + 2C^4H^6O^3.3CuO + C^4H^6O^3.CuO.$$

The following table exhibits the composition of several kinds of blue verdigris as determined by Berzelius and by Phillips:

	Calculation.		Berzelius.	Phillips.		
				French.	English.	
					Crystallised.	Compressed.
$2CuO$	160	43·24	43·34	43·5	43·25	44·25
$C^4H^6O^3$	102	27·57	27·45	29·3	28·30	29·62
$6H^2O$	108	29·19	29·21	25·2	28·45	25·51
Impurities	..	..	..	2·0	..	0·62
	370	100·00	100·00	100·0	100·00	100·00

The *sesquibasic acetate* is obtained in a state of purity by adding ammonia in small portions to a boiling concentrated solution of the normal salt, till the precipitate is just redissolved, and leaving the solution to cool; or by treating common green verdigris with cold or tepid water, and leaving the filtrate to evaporate. It is then deposited in bluish scales containing $2(C^2H^3O^2)^2Cu''.Cu''O + 6H^2O$. It gives off half its water at 60°, and becomes greenish.

Green Verdigris, according to Berzelius, is a mixture of this salt with small quantities of the bibasic and tribasic salts, sometimes also containing cuprous acetate and other impurities. It is manufactured at Grenoble by frequently sprinkling copper-plates with vinegar in a warm room; and in Sweden by disposing copper-plates in alternate layers with flannel cloths soaked in vinegar, till the green salt begins to form, then exposing them to the air and frequently moistening with water. The greenest kind contains, according to Berzelius, 49·9 per cent. of cupric oxide, and 13·5 per cent. of water and impurities; the pure sesquibasic salt contains 43·5 per cent. CuO.

The *tribasic acetate*, $(C^2H^3O^2)^2Cu''.2Cu''O + 2H^2O$, is the most stable of all the acetates of copper. It is obtained by exhausting blue verdigris with water; also by boiling the aqueous solution of the normal salt, or by heating it with alcohol, or again by digesting the same solution with cupric hydrate. The last method yields the salt in the form of a green powder; as obtained by the other methods, it forms a bluish powder composed of fine needles or scales. It gives off its water at 160°, and decomposes at a higher temperature, yielding acetic acid. Boiling water decomposes and turns it brown. The brown substance thus formed was regarded by Berzelius as a peculiar basic acetate, containing $C^4H^6O^3.48Cu''O$; but it is more probably a mixture of the tribasic salt with excess of oxide.

Acetate of Copper and Calcium. $(C^2H^3O^2)^2Ca''.(C^2H^3O^2)^2Cu'' + 8H^2O$.—Obtained by heating a mixture 1 atom of normal cupric acetate and 1 atom hydrate of calcium with 8 times its weight of water and sufficient acetic acid to dissolve the precipitated oxide of copper, and evaporating the green filtrate at a temperature between 25° and 27°. It forms large, blue, transparent, square prisms, often converted into octagonal prisms by truncation of the lateral edges. They effloresce slightly in the air; fall to powder at 75°, giving off acetic acid; and dissolve readily in water. Another cuprico-calcic acetate, $(C^2H^3O^2)^2Ca''.(C^2H^3O^2)^2Cu''.2Cu''O + 4H^2O$, often exists in crystallised verdigris: its optical properties differ from those of the normal cupric acetate.

Aceto-arsenite of Copper. $(C^2H^3O^2)^2Cu''.3(AsO^2)^2Cu''$, or $C^4H^6O^3.Cu''O + 3(As^2O^3.Cu''O)$.—*Schweinfurt green*, *Imperial green*, *Mitis green*, and when mixed with gypsum or heavy spar, *Neuwieder green*, *Mountain green*. Used as a pigment, and prepared on the large scale by mixing arsenious acid with cupric acetate and water. 5 parts of verdigris are made up to a thin paste, and added to a boiling solution of 4 parts or rather more of arsenious acid in 50 parts of water. The boiling must be well kept up, otherwise the precipitate assumes a yellow-green colour, from formation of arsenite of copper; in that case, acetic acid must be added, and the boiling continued a few minutes longer. The precipitate then becomes crystalline, and acquires the fine green colour peculiar to the aceto-arsenite. The salt is insoluble in water, and when boiled with water for a considerable time, becomes brownish and gives up acetic acid. Acids abstract the whole of the copper, and aqueous alkalis first separate blue cupric hydrate, which, when boiled with the liquid, is converted into black cupric oxide, and afterwards into red cuprous oxide, an alkaline arsenate being formed at the same time.

ACETATES OF IRON.—*a. Ferrous Acetate.* When metallic iron or the protosulphide is dissolved in strong acetic acid, and the solution concentrated, small colourless silky needles are obtained, which dissolve easily in water, and rapidly absorb oxygen from the air.

β. *Ferric Acetate.*—Obtained by dissolving ferric hydrate in acetic acid, or by decomposing a solution of ferric sulphate with acetate of lead. It is uncrystallisable and very soluble in water, forming a red-brown solution; soluble also in alcohol. The aqueous solution, when kept in a state of ebullition for about 12 hours, undergoes a remarkable modification, acquiring a brick-red colour, and remaining clear when viewed by transmitted light, but appearing opaque and opalescent by reflected light. At the same time, it loses entirely the metallic taste of iron salts, and acquires that of vinegar; it forms a brown instead of a blue precipitate with ferrocyanide of potassium, and no longer exhibits the characteristic red colour with sulphocyanides. Traces of sulphuric or phosphoric acid, or of alkaline salts, precipitate the whole of the iron in the form of a red-brown precipitate, which, at ordinary temperatures, is perfectly insoluble in acids, even the most concentrated; hydrochloric and nitric acids throw down a red granular precipitate, which, when perfectly freed from the acid mother-liquor, dissolves easily and completely in water. (Péan de St. Gilles, Ann. Ch. Phys. [3] xlvi. 47.) (See SUPPLEMENT.)

A mixture of the two acetates of iron, called *pyrolignite of iron* (*liqueur de ferraille, bouillon noir*), is prepared on the large scale by treating iron with wood-vinegar, in contact with the air. It is used as a mordant for black dyes; also for preserving wood.

ACETATES OF LEAD.—The normal acetate $(C^2H^3O^2)^2Pb''$, or $Pb''O.C^4H^6O^3$ (*Sugar of lead. saccharum Saturni, sel de Saturne, Bleizucker*) is prepared by dissolving oxide or carbonate of lead in acetic acid, wood-vinegar being used on the large scale, or by immersing plates of lead in vinegar in vessels exposed to the air. It crystallises in prisms containing $(C^2H^3O^2)^2Pb'' + H^2O$, and belonging to the monoclinic system. Ordinary combination: $\infty P . 0P . \infty P \infty$, sometimes with the face $0P$ predominating, so as to give the crystals a tabular form. The length of the orthodiagonal is to that of the clino-diagonal, as 0·4197 to 1. Inclination of the axes = 70° 28′. Inclination of the faces: $\infty P : \infty P = 128°$; $\infty P : \infty P\infty = 116°$; $\infty P : 0P = 98° 30'$; $0P : \infty P\infty = 109° 32$. Cleavage parallel to $0P$ and $\infty P\infty$. The crystals are efflorescent, soluble in 0·59 parts of water at 15°·5 (60° F.), and in 8 parts of alcohol. The salt has a sweet, astringent taste, and is very poisonous. It melts at 75°·5; begins to give off water with a portion of its acid a little above 100°; and is completely dehydrated at 280°. Above that temperature it decomposes, giving off acetic acid, carbonic anhydride, and acetone, and leaving metallic lead very finely divided and highly combustible. The aqueous solution is partially decomposed by the carbonic acid of the air, carbonate of lead being precipitated, and a portion of acetic acid set free, which prevents further decomposition. The solution is not precipitated by ammonia in the cold, but yields crystals of oxide of lead when heated with a large excess of ammonia. Normal acetate of lead forms crystalline compounds with chloride of lead and with peroxide of lead.

(Berzelius, Ann. Chim. xciv. 292; Schindler, Brandes' Archiv, xli. 129; Payen, Ann. Ch. Phys. [2] lxv. 238, and lxvi. 37; Wittstein, Buchner's Repert. lxxxiv. 170; Gm. viii. 310; Gerh. i. 736.)

Four *basic acetates* of lead have been described, viz.:

The sesquibasic acetate	$2(C^2H^3O^2)^2Pb''. Pb''O$	or	$2C^4H^6O^3.3Pb''O$.
Bibasic	$(C^2H^3O^2)^2Pb''. Pb''O$	or	$C^4H^6O^3.2Pb''O$.
Tribasic	$(C^2H^3O^2)^2Pb''.2Pb''O$	or	$C^4H^6O^3.3Pb''O$.
Sexbasic	$(C^2H^3O^2)^2Pb''.5Pb''O$	or	$C^4H^6O^3.6Pb''O$.

All of these, however, except the tribasic salt, are of rather doubtful composition.

The *sesquibasic salt* is obtained by heating the normal salt till it melts, and subsequently solidifies in a white porous mass. By dissolving the residue in water and evaporating, the salt is then obtained in nacreous laminæ containing $2[2(C^2H^3O^2)^2Pb.PbO] + H^2O$. It is more soluble in water and alcohol than the normal acetate, and forms alkaline solutions. (Payen, Schindler.)

The *bibasic acetate* is deposited in the crystalline form when oxide of lead (massicot) is dissolved in the proper proportion in the normal acetate. The crystals contain 2 atoms of water, half of which is given off at 70°, and the rest at 100°. (Schindler.)

The *tribasic acetate* is obtained in the crystalline form, when a solution of the normal salt, saturated in the cold and mixed with $\frac{1}{5}$ of its volume of ammonia, is left to evaporate; also by digesting 7 parts of massicot in a solution of 6 parts of the crystallised normal acetate. It forms long silky needles, very soluble in water, but insoluble in alcohol. The aqueous solution becomes turbid on exposure to the air. According to Payen, the crystals contain $(C^2H^3O^2)^2Pb''.Pb''O + H^2O$, but, according to Berzelius, they are anhydrous.

The *sexbasic salt* is obtained by digesting the solution of either of the preceding salts with excess of oxide of lead. A crystalline precipitate is then formed, which dissolves sparingly in boiling water, and separates in silky needles containing $(C^2H^3O^2)^2Pb''.5Pb''O + \frac{3}{2}H^2O$. (Berzelius.)

The liquid called *Goulard's lotion*, *lead-vinegar*, *acetum Saturni*, is a mixture of the aqueous solutions of these basic acetates of lead, chiefly the tribasic salt. It is prepared by digesting oxide of lead in acetic acid, or in a solution of the normal acetate. It is an alkaline liquid which is decomposed by the carbonic acid in the air. It precipitates a large number of vegetable substances, such as gum-resins, colouring matters, &c. and from its power of coagulating mucus, is much used as a lotion for wounds and sores.

Acetate of Lithium. $C^2H^3O^2Li + 2\,H^2O$.—Right rhomboïdal prisms, deliquescent in moist air, soluble in less than a third of their weight of water at 15°, and in 4·6 pts. of alcohol of sp. gr. 0·81 at 14°.

Acetate of Manganese.—Pale rose-coloured splinters or small prisms grouped together; soluble in 3 pts. of water.

Acetates of Mercury.—*Mercurous acetate*, $(C^2H^3O^2)^2(Hg^2)''$, is obtained by precipitating mercurous nitrate with a soluble acetate. It forms anhydrous micaceous laminæ, sparingly soluble in water. Heat decomposes it into metallic mercury, carbonic anhydride, and acetic acid.

Mercuric Acetate, $(C^2H^3O^2)^2Hg''$ or $C^4H^6O^3.Hg''O$, is prepared by dissolving red oxide of mercury in warm acetic acid. It crystallises in brilliant micaceous laminæ, soluble in their own weight of water at 10°, and somewhat more soluble in boiling water. Alcohol and ether decompose it, separating mercuric oxide.

Acetate of Mercurammonium, $(C^2H^3O^2)^2.(N^2H^6Hg'')'' + 2H^2O$, is obtained by agitating recently precipitated mercuric oxide with a solution of acetate of ammonium. It crystallises in rhomboïdal plates, very soluble in water, insoluble in alcohol. At 100° it gives off from 30 to 31 per cent. of its weight, and is converted into *acetate of tetramercurammonium*, $(C^2H^3O^2)^2(N^2Hg^4)''$.

Acetate of Nickel crystallises in apple-green prisms, slightly efflorescent, soluble in 6 pts. of cold water, insoluble in alcohol. The solution is decomposed by hydrosulphuric acid, which throws down sulphite of nickel.

Acetates of Potassium.—*Normal acetate.* $C^2H^3O^2K$ or $C^4H^6O^3.K^2O$. (*Terra foliata Tartari*, *Arcanum Tartari*, *Tartarus regeneratus*, *Blättererde*, *geblätterte Weinsteinerde*.)

This salt exists in the juices of many plants. It is prepared by dissolving carbonate of potassium in acetic acid. When brown vinegar is used for the purpose, the carbonate of potassium should be added by small portions, so as to keep the solution constantly acid. The object of this precaution is to avoid the formation of coloured products by the contact of free alkali with the foreign matters in the vinegar. Pure acetate of potassium is a white salt, difficult to crystallise, very soluble in water and deliquescent, soluble also in alcohol, and precipitated by ether from the alcoholic solution. Carbonic acid gas, passed into a solution of the salt in absolute alcohol, throws down carbonate of potassium, and liberates acetate of ethyl. The salt melts below a red heat, forming a limpid oil, which solidifies in an extremely deliquescent mass on cooling. It requires a very high temperature to decompose it, and then gives off acetone, empyreumatic oil, and inflammable gases, and leaves a residue of carbonate of potassium mixed with charcoal. Heated with excess of hydrate of potassium, it yields carbonate of potassium and marsh gas:

$$C^2H^3O^2K + KHO = CH^4 + CO^3K^2.$$

Heated with arsenious anhydride, it yields cacodyl. (See **Arsenides of Methyl.**) Chlorine, passed into the aqueous solution of acetate of potassium, liberates carbonic anhydride, and forms a bleaching liquid, which however loses its decolorising power on exposure to the air. When an electric current is passed through a strong aqueous solution of acetate of potassium separated into two parts by a porous diaphragm, hydrogen alone is evolved at the negative pole; while, at the positive pole, there is evolved a gaseous mixture of methyl and carbonic anhydride, together with acetate of methyl and a small quantity of oxide of methyl. The principal decomposition is represented by the equation:

$$2C^2H^4O^2 = C^2H^6 + 2CO^2 + H^2,$$

the acetate and oxide of methyl being secondary products. (Kolbe, Ann. Ch. Pharm. lxix. 257.)

Acid Acetate or *Diacetate of Potassium*, $C^2H^3O^2K.C^2H^4O^2$, or $C^4H^6O^3.H^2O + C^4H^6O^3.K^2O$.

When the normal acetate is evaporated with an excess of strong acetic acid, this acid salt is deposited in needles or laminæ, or by slow evaporation in long flattened prisms, apparently belonging to the rhombic system. It is very deliquescent, melts at 148°, and decomposes at 200°, giving off crystallisable acetic acid. On this property is founded an easy method of obtaining the crystallisable acid.

Diacetate of potassium is formed when the normal acetate is distilled with butyric or valerianic acid; but neither of these acids decomposes the salt thus produced. Hence, when butyric or valerianic acid is mixed with acetic acid, a separation more or less complete may be effected by half neutralising the liquid with potash, and distilling. If the acetic acid is in excess, diacetate of potassium alone remains behind, the whole of the valerianic or butyric acid passing over, together with the remainder of the acetic acid. If, on the contrary, the other acid is in excess, it passes over, unmixed with acetic acid, and the residue consists of diacetate of potassium mixed with butyrate or valerate. By repeating the process a certain number of times, either on the acid distillate or on the acid separated from the residue by distillation with sulphuric acid, complete separation may be effected. (Liebig, Ann. Ch. Pharm. lxxi. 355.)

Anhydrous Diacetate of Potassium, $2C^2H^3O^2K.C^4H^6O^3 = K^2O.2C^4H^6O^3$, is produced by dissolving melted acetate of potassium in acetic anhydride at the boiling heat, or by the action of potassium on acetic anhydride. Forms colourless needles very soluble in water, less deliquescent than normal acetate of potassium. It is decomposed by heat, giving off acetic anhydride. (Gerhardt, Ann. Ch. Phys. [3] xxxvii. 317.)

Acetate of Silver, $C^2H^3O^2Ag$.—Obtained by precipitating nitrate of silver with acetate of sodium. Crystallises from boiling water in thin, flexible laminæ; soluble in 100 pts. of cold water.

Acetate of Sodium, $C^2H^3O^2Na$ or $C^4H^6O^3.Na^2O$. *Terra foliata Tartari crystallisabilis, Terre foliée minérale.*—Prepared either by dissolving carbonate of sodium in acetic acid, or by decomposing acetate of calcium with sulphate of sodium. Forms large transparent prisms belonging to the monoclinic system. Ordinary combination: $\infty P . [\infty P\infty] . 0P . -P$; more rarely with $\infty P\infty$, $+P$, $+2P\infty$. Ratio of the axes: $a : b : c = 0·8348 : 1 : 0·8407$. Angle of the axes = 68° 16′. Inclination of the faces: $\infty P : \infty P$ in the plane of the orthodiagonal and principal axis = 95°·30; $-P : +P$, forming the obtuse edges of the pyramid $+P$ in the plane of the oblique diagonal and principal axis = 117°·32; $\infty P : 0P$ = 75°·35. Cleavage parallel to $0P$ and ∞P. (Gerhardt, Traité i. 725.) The crystals contain 3 at. water. They effloresce slightly in dry air, completely at a moderate heat, and melt below 100°. They dissolve in 3·9 pts. of water at 6°, in 2·4 pts. at 37°, and in 1·7 pts. at 48° (Osann). According to Berzelius, a solution saturated at the boiling heat, contains 0·48 pts. water to 1 pt. of salt, and boils at 124°·4. The salt is less soluble in alcohol. It has a bitter, pungent, but not disagreeable taste.

Acetate of Strontium crystallises like the barium-salt in two different forms, containing different quantities of water. The salt deposited at 15°, contains 4·23 p. c. water $(2(C^2H^3O^2)^2Sr'' + H^2O)$, and that which is deposited at low temperatures contains $(C^2H^3O^2)^2Sr'' + 2H^2O$. The latter forms prisms belonging to the monoclinic system, $\infty P : \infty P$ = 124° 54′; $\infty P . \infty P\infty$ = 107° 33′; $0P : P\infty$ = 153°·12. Cleavage indistinct. parallel to $\infty P\infty$.

Acetate of Tin.—Boiling acetic acid dissolves tin slowly, with evolution of hydrogen; the hydrated protoxide dissolves easily in the boiling acid, and the solution evaporated to a syrup and covered with alcohol yields small colourless crystals. Hydrated dioxide of tin also dissolves in acetic acid, and the solution yields a gummy mass when evaporated. Dichloride of tin forms a crystalline compound with glacial acetic acid.

Acetate of Uranium.—*Uranous Acetate*, obtained by evaporating a solution of oxide in acetic acid, crystallises in green needles grouped in warty masses.

Uranic Acetate, or *Acetate of Uranyl*, $(C^2H^3O^2)^2(U^2O^2)''$[*] or $C^4H^6O^3.U^2O^3$, is obtained by heating uranic nitrate till it begins to evolve oxygen, dissolving the yellowish red mass, which still contains nitric acid, in warm concentrated acetic acid, and evaporating to the crystallising point; all the nitric acid then remains in the mother liquid. From a very concentrated, or from an acid solution slightly cooled, the salt separates in beautiful rhomboïdal prisms, $(C^2H^3O^2)^2(U^2O^2)'' + 2H^2O$, belonging to the monoclinic system; boiling water decomposes them with separation of uranic hydrate, but the solution yields the same crystals by evaporation. A more dilute solution cooled below 10° deposits square-based octohedrons containing $(C^2H^3O^2)^2(U^2O^2)'' + 3H^2O$, or

[*] Uranyl, U^2O^2, is a diatomic radicle, supposed to exist in the uranic compounds. (See Uranium.)

$(C^2H^3O^2)^2(U^2O^2)'' + 3H^2O$. They give off ⅓ of their water at 200°, and the rest at 275°, leaving the yellowish-red anhydrous salt.

Uranic acetate combines with the acetates of the more basic metals, forming double acetates. The *ammonium*, *potassium*, and *sodium* salts are obtained by adding the solutions of the carbonates to a solution of uranic acetate, till a precipitate is formed consisting of a uranate of the alkali-metal, redissolving this precipitate in a slight excess of acetic acid, and cooling the solution till it crystallises. The other double salts of this group are obtained by boiling the carbonates with uranic acetate, till the whole of the uranic oxide is precipitated, redissolving the precipitate in acetic acid, and evaporating. The *lead* and *cadmium* salts consist of 1 at. of uranic acetate combined with 1 at. of the monobasic acetate, their formulæ being $(C^2H^3O^2)^2Pb''.(C^2H^3O^2)^2(U^2O^2)'' + 6H^2O$ and $(C^2H^3O^2)^2Cd''.(C^2H^3O^2)^2(U^2O^2)'' + 5H^2O$. All the rest contain 2 at. uranic acetate with 1 at. of the diatomic metal, their general formula being $(C^2H^3O^2)^2M''.(C^2H^3O^2)^2(U^2O^2)'' + nH^2O$. Most of these salts crystallise with facility, the potassium and silver salts in the quadratic system; the sodium salt forms regular tetrahedrons. The strontium and calcium salts are very soluble in water, and difficult to crystallise. The sodium salt is anhydrous; the rest contain water of crystallisation. (Wertheim, J. pr. Chem. xxix. 209; Weselsky, Chem. Gaz. 1858, 390.)

Acetate of Yttrium, $(C^2H^3O^2)^2Y'' + 2H^2O$.—Rhomboïdal prisms with trihedral summits. They are permanent in the air at ordinary temperatures; give off their water, and become opaque at 100°; dissolve in 9 pts. of cold water, and in a smaller quantity of boiling water; also in alcohol. (Berlin.)

Acetate of Zinc, $(C^2H^3O^2)^2Zn'' + 3H^2O$ or $C^4H^6O^3.ZnO + 3H^2O$.—Obtained by dissolving either the metal, the oxide, or the carbonate in acetic acid. Crystallises in nacreous efflorescent laminæ belonging to the monoclinic system (Kopp's Krystallographie, p. 310). Ordinary combination : $0P . \infty P . \infty P\infty . + P . + 2P\infty$, the face $0P$ predominating. $a : b : c = 0·4838 : 1 : 0·87$. Inclination of axes = 46° 30′. Inclination of faces, $\infty P : \infty P$ in the plane of orthodiagonal and principal axis = 112° 36′; $\infty P . 0P$ = 112° 28′; $0P : \infty P\infty$ = 113° 30′; $0P : P\infty$ = 80°; $0P : +P$ = 75° 30′. Cleavage parallel to $0P$. The salt dissolves very readily in water. At 100° it melts, gives off its water with a little acetic acid, then solidifies, and does not liquefy again till heated to 190° or 195°, at which temperature anhydrous acetate of zinc sublimes in nacreous scales. At higher temperatures, complete decomposition ensues. (Larocque, Recueil des Trav. de la Soc. Pharm. 1847–54.)

ACETIC ACID, SUBSTITUTION PRODUCTS OF.—The following acids (which will be more fully described hereafter), are derived from acetic acid by substitution:

Bromacetic acid	$\left.\begin{matrix}C^2H^2BrO\\H\end{matrix}\right\}O$
Dibromacetic acid	$\left.\begin{matrix}C^2HBr^2O\\H\end{matrix}\right\}O$
Chloracetic acid	$\left.\begin{matrix}C^2H^2ClO\\H\end{matrix}\right\}O$
Trichloracetic acid	$\left.\begin{matrix}C^2Cl^3O\\H\end{matrix}\right\}O$
Iodacetic acid	$\left.\begin{matrix}C^2H^2IO\\H\end{matrix}\right\}O$
Diniod-acetic acid	$\left.\begin{matrix}C^2HI^2O\\H\end{matrix}\right\}O$
Thiacetic acid	$\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}S$

The brominated and chlorinated acids are produced by the direct action of bromine and chlorine on acetic acid; the iodated acids by the action of iodide of potassium on bromacetate and dibromacetate of ethyl; and thiacetic acid by treating glacial acetic acid with pentasulphide of phosphorus (p. 11). All these acids are monatomic, like acetic acid itself, correspond to it in nearly all their reactions, and are formed upon the same type.

ACETIC ANHYDRIDE. $C^4H^6O^3 = (C^2H^3O)^2O$. *Anhydrous Acetic acid, Oxide of Acetyl; Acetate of Acetyl.*—(Gerhardt, Traité, i. 711.)

This compound is obtained: 1. By the action of oxychloride of phosphorus, $POCl^3$, on acetate of potassium. The acetate deprived of water by fusion, is introduced into a tubulated retort, and the oxychloride of phosphorus admitted through the tubulus, drop by drop. A violent action takes place, the mixture becoming very hot without the application of external heat, and a liquid distils over, which is the chloride of acetyl, while tribasic phosphate of potassium remains in the retort:

$$3C^2H^3KO^2 + POCl^3 = PO^4K^3 + 3(C^2H^3O.Cl).$$

If now this liquid be poured back again three or four times into the retort, so that it may remain for some time in contact with the acetate of potassium, that salt being also in excess and pretty strongly heated, a further action takes place between the acetate of potassium and the compound $C^2H^3O.Cl$, the result of which is the formation of acetic anhydride: thus,

$$C^2H^3KO^2 + C^2H^3O.Cl = KCl + C^4H^6O^3.$$

The acetic anhydride enters into combination with the acetate of potassium, and a considerable degree of heat is required to destroy this compound and cause the anhydride to distil over. The distillate is more or less contaminated with acetic acid and chloride of acetyl; but on redistilling the crude product, these impurities pass over at the commencement, before the temperature rises to 137°·5, after which the pure anhydride distils over.—2. By the action of terchloride of phosphorus on acetate of potassium. When the liquid chloride is added drop by drop to the acetate of potassium (about 1 pt. PCl^3 to more than 2 pts. of the acetate), the action begins without application of heat, and chloride of acetyl, amounting in quantity to about half the chloride of phosphorus used, distils over mixed with a small quantity of chloride of phosphorus. On heating the residue after this action has ceased, acetic anhydride distils over free from chloride, and in quantity equal to about a third of the chloride of phosphorus used. The product contains a small quantity of a phosphorus-compound, which causes it to impart a brownish colour to nitrate of silver; but it may be freed from this impurity by a second distillation with acetate of potassium. — 3. By the action of chloride of benzoyl, $C^7H^5O.Cl$, on fused acetate of potassium. The first products of the action are chloride of potassium and acetate of benzoyl, $C^9H^8O^3$:

$$C^7H^5O.\,Cl + C^2H^3KO^2 = KCl + \left.\begin{matrix}C^7H^5O\\C^2H^3O\end{matrix}\right\}O.$$

But if the acetate of potassium is in excess, and the mixture is heated somewhat above the temperature at which the original substances act upon each other, a further action takes place, and a colourless liquid distils over, which is acetic anhydride, while benzoic anhydride remains in the retort in combination with benzoate of potassium. These new products are formed by double decomposition between 2 atoms of the benzoic acetate:

$$2\left\{\begin{matrix}C^7H^5O\\C^2H^3O\end{matrix}\right\}O = \left.\begin{matrix}C^7H^5O\\C^7H^5O\end{matrix}\right\}O + \left.\begin{matrix}C^2H^3O\\C^2H^3O\end{matrix}\right\}O$$

4. By the action of chloride of acetyl, C^2H^3OCl, on dry benzoate of sodium. The reaction, which takes place without the aid of heat, is precisely similar to the preceding.

Acetic anhydride is a colourless, very mobile, strongly refracting liquid, having a powerful odour, similar to that of the hydrated acid, but stronger, and recalling at the same time that of the flowers of the white-thorn. Sp. gr. 1·073 at 20°·5, which is nearly that of the hydrated acid, $C^2H^4O^2 + H^2O$, at its greatest density. Boiling point 137°·5 under a pressure of 750 mm. Vapour density = 3·47 (by calculation 3·531 for a condensation to 2 volumes).

Fuming sulphuric acid becomes heated by contact with acetic anhydride, carbonic anhydride being given off and a conjugated acid produced, which forms a gummy salt with lead. *Potassium* acts violently on acetic anhydride, evolving a gas which does not take fire if the potassium be introduced by small portions at a time. The liquid, after a while, solidifies into a mass of needles, consisting of a compound of acetic anhydride with acetate of potassium (p. 33). An oily substance is also produced, having a very pleasant ethereal odour. Finely divided *zinc* acts upon acetic anhydride in a similar manner, but less energetically, and only when heated in the water bath; hydrogen gas is then given off, and a soluble salt formed, which is deposited in microscopic crystals on the surface of the metal, and greatly retards the action. On saturating the excess of acetic acid in the residue with carbonate of sodium, the ethereal odour above mentioned is perceived. The hydrogen evolved, if collected immediately, has the same odour, burns with a bluish flame, and the product of the combustion renders lime-water turbid; but after passing through potassium, it is inodorous, and when burnt yields nothing but pure vapour of water.

Acetic anhydride does not combine immediately with *water*, but when poured into that liquid, falls to the bottom in oily drops which dissolve after a while, if the liquid is heated or agitated. It absorbs water from the air, and must therefore be kept in well closed vessels.

Acetic anhydride combines with *aldehydes*. With ordinary aldehyde, it forms a liquid compound, $C^4H^6O^3 . C^2H^4O$ (Geuther), and a similar compound with valeral. $C^4H^6O^3 . C^5H^{10}O$ (Guthrie and Kolbe); also with bitter almond oil (Geuther).

ACETOBENZOIC, or BENZOACETIC ANHYDRIDE, $C^9H^8O^3 = \left.\begin{matrix}C^2H^3O\\C^7H^5O\end{matrix}\right\}O$. *Acetate of Benzoyl, Benzoate of Acetyl.*—Obtained by the action of chloride of acetyl on benzoate of sodium. Heavy oil smelling like Spanish wine. Neutral to litmus. Boils at 120° C. and is resolved into acetic and benzoic anhydrides (p. 35). Resolved into acetic and benzoic acids by boiling with water, and more quickly with alkalis.

ACETO-CINNAMIC ANHYDRIDE, $C^2H^3O.C^9H^7O.O$. *Acetate of Cinnamyl, &c.*—A very instable product obtained by the action of chloride of acetyl on cinnamate of sodium. Oil heavier than water, something like the preceding compound.

ACETO-CUMINIC ANHYDRIDE, $C^2H^3O . C^{10}H^{11}O . O$. *Acetate of Cumyl.*—Resembles the preceding compounds. In the moist state it quickly turns acid, and yields beautiful laminæ of cuminic acid, the odour of acetic acid becoming perceptible at the same time.

ACETO-SALICYLIC ANHYDRIDE, $C^2H^3O . C^7H^5O^2.O$. *Acetate of Salicyl, &c.*—Salicylate of sodium is strongly attacked by chloride of acetyl, even at ordinary temperatures, the mixture liquefying at first, but becoming perfectly hard in a few seconds. The product dissolves with effervescence in carbonate of sodium, the anhydride being converted into acetate and salicylate of sodium. (Gerhardt, Traité, iii. 319.)

ACETIC ETHERS. These compounds are the acetates of the alcohol-radicles, and may be divided into the following groups:

1. Monatomic Acetic Ethers.

ACETATE OF ALLYL, $C^2H^3O.C^3H^5$.—Prepared by treating acetate of silver with iodide of allyl, and rectifying once or twice over acetate of silver. It is a colourless liquid, lighter than water, having a pungent, aromatic odour, and boiling between 98° and 100°. Boiling potash decomposes it into acetate of potassium and allyl-alcohol. (Cahours and Hofmann, Chem. Soc. Qu. J. x. 322.)

ACETATE OF AMYL, or ACETATE OF PENTYL, $C^2H^3O^2.C^5H^{11}$.—This compound is slowly produced when amylic alcohol is left in contact with acetic acid, and may be conveniently prepared by distilling 2 pts. of acetate of potassium, or 3 pts. of dehydrated acetate of lead, with 1 pt. of strong sulphuric acid, and 1 pt. of amylic alcohol, agitating the distillate with milk of lime, then dehydrating over chloride of calcium, and rectifying. It is a transparent, colourless liquid, of sp. gr. 0·8572 at 21°, and boiling at 133·3°, under a pressure of 27″ 8‴, with a platinum wire immersed in it. Vapour-density 4·458. Odour ethereal and aromatic, like that of acetate of ethyl. It is insoluble in water, but dissolves in *alcohol, ether*, and *fusel oil*. It is decomposed very slowly by aqueous potash, but quickly by alcoholic potash, yielding amylic alcohol and acetate of potassium. Chlorine passed through it at 100°, converts it into *di-chlorinated acetate of amyl*, $C^7H^{12}Cl^2O^2$, and this, by the action of chlorine in sunshine, is converted into a higher chlorine-compound.

ACETATE OF BENZYL, $C^2H^3O^2.C^7H^7$.—Produced by treating 2 vol. benzyl-alcohol with a mixture of 1 vol. sulphuric acid and 4 or 5 vol. acetic acid, or by boiling chloride of benzyl with alcoholic acetate of potassium. Colourless oil, heavier than water, and having a very agreeable odour, like that of pears. Boils at 210° C. Boiled with potash-ley, it yields acetate of potassium and benzylic alcohol. (Cannizzaro, Ann. Ch. Pharm. lxxxviii. 130.)

ACETATE OF ETHYL. *Acetic ether, Ethylic Acetate, Essigäther, Essignaphtha, Essigsaures Æthyloxyd, Ether acétique.* $C^4H^8O^2 = C^2H^3O^2.C^2H^5$ or $C^4H^6O^3.C^4H^{10}O$. (Lauragais, Journ. d. Sçavans, 1759, 324; Thénard, Mém. d'Arcueil, i. 153; Dumas and Boullay, J. Pharm. xiv. 113; Liebig, Ann. Ch. Pharm. v. 34; xxx. 144; Gm. viii. 493; Gerh. i. 743).—Discovered by Lauragais in 1759. It is formed by heating alcohol with acetic acid, or with an acetate and strong sulphuric acid, or by distilling ethyl-sulphate of calcium or potassium with glacial acetic acid. The best mode of preparing it is to distil a mixture of 3 pts. of acetate of potassium, 3 pts. of absolute alcohol, and 2 pts. of sulphuric acid; or 10 pts. of acetate of sodium, 6 pts. of alcohol, and 15 pts. of sulphuric acid; or 16 pts. of dry acetate of lead, 4½ pts. of alcohol, and 6 pts. of sulphuric acid. The acid is first mixed with the alcohol, and the liquid poured upon the salt reduced to fine powder. The mixture is then distilled to dryness, the heat being moderate at first, but increased towards the end of the process. The product is purified by digesting it with chloride of calcium and rectifying the decanted liquid.

Acetate of ethyl is a colourless liquid, having a pleasant ethereal odour. Sp. gr. 0·91046 at 0° (Kopp); 0·932 at 20° (Gössmann). Boils at 74°·3, when the barometer stands at 760 mm. (Kopp). Vapour-density 3·06 (Boullay and Dumas). It dissolves in 11 or 12 pts. of water, at ordinary temperatures (Mohr, Arch. Pharm. [2] lxv. 1), in all proportions of alcohol and ether. It burns with a yellowish flame, giving off the odour of acetic acid, and leaving that acid in the liquid state. It is permanent when dry, but in the moist state gradually decomposes into alcohol and acetic acid. The same decomposition takes place more quickly under the influence of alkalis. Heated with strong sulphuric acid, it is resolved into oxide of ethyl and acetic acid. Hydrochloric acid converts it into acetic acid and chloride of ethyl.

Action of Chlorine on *Acetate of Ethyl*. (Malaguti, Ann. Ch. Phys. [2] xx. 367; ibid. [3] xvi. 2, 58; Leblanc, ibid. [3] 197; Cloez, ibid. [3] xvii. 304.,— When acetate of ethyl is introduced into a bottle filled with dry chlorine gas, in the proportion of 1 atom acetate of ethyl to 8 atoms chlorine, and the action allowed to go on, first in the shade and afterwards with continually greater exposure to sunshine, a number of chlorinated compounds are formed in which 2, 3, 4, 5, 6, 7, and 8 atoms of hydrogen in the acetate of ethyl are successively replaced by an equal number of chlorine-atoms. It is however not always possible to obtain the particular compound required, the compounds $C^4H^6Cl^2O^2$, $C^4HCl^7O^2$, and $C^4Cl^8O^2$, being the only ones that can be produced with certainty. Other products are also formed, among which are acetic acid, trichloracetic acid, and sesquichloride of carbon. If the acetate of ethyl is at once exposed to sunshine in contact with chlorine, an explosion takes place, attended with deposition of charcoal.

Dichlorinated Acetate of Ethyl, $C^4H^6Cl^2O^2$, is the product obtained when the acetate of ethyl is kept cool and in the shade during the action of the chlorine. On distilling the product to separate the more volatile portions, till the boiling point rises to 110°, washing the brownish residue with water, and drying it over lime and sulphuric acid, the compound is obtained as a transparent colourless oil, of sp. gr. 1·301 at 12°. It smells somewhat like acetic acid, has a peppery taste, and produces irritation in the throat. It is slowly decomposed by water, yielding hydrochloric and acetic acids. $C^4H^6Cl^2O^2 + 2H^2O = 2C^2H^4O^2 + 2HCl$; slowly also by aqueous potash, but quickly by alcoholic potash, yielding acetate and chloride of potassium. (Malaguti.)

Trichlorinated Acetate of Ethyl, $C^4H^5Cl^3O^2$, was obtained by exposing the dichlorinated compound for some time to the action of chlorine in a bottle, covered at the upper part with black paper, so that the light fell only on the lower part of the liquid. It resembles the preceding compound, but cannot be distilled without alteration. It is isomeric with trichloracetate of ethyl, $C^2Cl^3O^2.C^2H^5$. See TRICHLORACETIC ACID. (Leblanc.)

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Perchlorinated Acetate of Ethyl, $C^4Cl^8O^2$, is prepared by exposing di- or tri-chlorinated acetate of ethyl to the brightest summer sunshine, and at the same time heating it to 110°; even then the substitution takes place very slowly (Leblanc). The product is distilled in an atmosphere of carbonic acid, to remove free chlorine. It is a colourless oil, which remains liquid at a few degrees below 0°, and has a strong pungent odour like that of chloral. Sp. gr. 1·79 at 25°. Boils, with partial decomposition, at 245° (Leblanc). When its vapour is passed through a tube filled with fragments of glass, and heated to 400°, it is partly converted into the isomeric compound chloraldehyde, C^2Cl^4O (Malaguti). In contact with water or moist air, it is gradually decomposed, yielding trichloracetic and hydrochloric acids. A similar decomposition is instantly produced by strong aqueous potash (Leblanc):

$$C^4Cl^8O^2 + 2H^2O = 2C^2HCl^3O^2 + 2HCl.$$

Ammonia, either gaseous or dissolved in water, acts strongly on the compound, producing sal-ammoniac and trichloracetamide (Malaguti):

$$C^4Cl^8O^2 + 2NH^3 = 2HCl + 2C^2H^2Cl^3NO$$

With absolute alcohol, the compound becomes strongly heated, and is completely converted into hydrochloric acid and trichloracetate of ethyl (Malaguti):

$$C^4Cl^8O^2 + 2C^2H^6O = 2HCl + 2C^4H^5Cl^3O^2.$$

When exposed for a long time to the action of chlorine, it yields crystals of sesquichloride of carbon. (Leblanc.)

Perchloracetic ether may be regarded as a *trichloracetate of pentachlorethyl*, $C^2Cl^3O^2 . C^2Cl^5$; and in like manner, all the preceding compounds which contain more than 3 atoms of chlorine, may be viewed as trichloracetates of ethyl-radicles, in which the H is more or less replaced by Cl: *e.g.* pentachloracetic ether, $C^4H^3Cl^5O^2 = C^2Cl^3O^2 . C^2H^3Cl^2$. Some of them appear however to be susceptible of isomeric modifications.

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Preparation.—1. Two pts. of wood-spirit are distilled with 1 pt. of glacial acetic acid and 1 pt. sulphuric acid; the distillate is shaken up with chloride of calcium, the acetate of methyl then rising to the top; and this product is freed from sulphurous acid by agitation with quicklime, and from wood-spirit by 24 hours' contact with chloride of calcium, which takes up the latter substance (Dumas and Peligot).—2. When 1 part of wood-spirit is distilled with 1 pt. acetate of potassium and 2 pts. of sulphuric acid, acetate of methyl passes over first, then sulphurous acid, acetic acid, methylic oxide, and a small quantity of methylic sulphate. The first receiver must therefore be removed as soon as sulphurous acid begins to escape; its contents shaken up with water; and the separated ether rectified over chloride of calcium and quicklime (Weidmann and Schweizer).—3. A mixture of 3 pts. wood-spirit, 14½ pts. dehydrated acetate of lead, and 5 pts. sulphuric acid is distilled; the distillate is shaken up with milk of lime; and the stratum of methylic acetate which rises to the surface is dehydrated by repeated treatment with chloride of calcium, then decanted from the lower liquid, and rectified. (H. Kopp.)

Acetate of methyl is a colourless liquid, having a very agreeable odour, like that of acetate of ethyl, sp. gr. 9·0085 at 21°; 0·9562 at 0° (Kopp). Boiling point, 56·3° under a pressure of 760 mm. (Kopp, Pogg. Ann. lxii. 1); 55° under a pressure of 762 mm. (Andrews, Chem. Soc. Qu. J. i. 27). Vapour-density 2·563 (Dumas and Péligot), by calculation 2·564. Index of refraction 1·3576. (Delffs, Pogg. Ann. lxxxi. 470.)

Acetate of methyl dissolves in water, and mixes in all proportions with alcohol and ether. The aqueous solution suffers but little decomposition by boiling. Solutions of caustic alkalis convert the compound into wood-spirit and an alkaline acetate. When poured on pulverised soda-lime, it is decomposed with violence, yielding a mixture of acetate and formate of sodium, and giving off hydrogen. In contact with strong sulphuric acid, it becomes heated, gives off acetic acid, and forms methylsulphuric acid. With chlorine it forms a number of substitution-products.

Dichlorinated Acetate of Methyl, $C^3H^4Cl^2O^2$, is formed by passing dry chlorine gas through acetate of methyl, assisting the action by a gentle heat towards the end. It is purified like the corresponding ethyl-compound. It is a colourless neutral liquid, having a pungent odour; its taste is sweet at first, but afterwards alliaceous and burning. Sp. gr. 1·25. Boils between 145° and 148°, but begins to decompose and give off fumes at 138°. It burns with a yellow flame, edged with green at the bottom. It is decomposed slowly by water, quickly by aqueous potash, and violently by alcoholic potash, yielding formic, acetic, and hydrochloric acids:

$$C^3H^4Cl^2O^2 + 2H^2O = CH^2O^2 + C^2H^4O^2 + 2HCl.$$

This compound is isomeric if not identical with dichlorinated formate of ethyl. (Malaguti, Ann. Ch. Phys. [2] lxx. 379.)

Trichlorinated Acetate of Methyl, $C^3H^3Cl^3O^2$, is obtained by passing chlorine very slowly into acetate of methyl, as long as any decomposition takes place, and purifying the product by repeated fractional distillation. It is a colourless oily liquid, heavier than water, boiling at 145°, and distilling without decomposition. It is decomposed by caustic potash, yielding chloride and formate of potassium, and *chloromethylase*, CHCl:

$$C^3H^3Cl^3O^2 + 2K^2O = 2KCl + 2CHKO^2 + CHCl.$$

Acetate of ethyl is a colourless liquid, having a pleasant ethereal odour. Sp. gr. 0·91046 at 0° (Kopp); 0·932 at 20° (Gössmann). Boils at 74°·3, when the barometer stands at 760 mm. (Kopp). Vapour-density 3·06 (Boullay and Dumas). It dissolves in 11 or 12 pts. of water, at ordinary temperatures (Mohr, Arch. Pharm. [2] lxv. 1), in all proportions of alcohol and ether. It burns with a yellowish flame, giving off the odour of acetic acid, and leaving that acid in the liquid state. It is permanent when dry, but in the moist state gradually decomposes into alcohol and acetic acid. The same decomposition takes place more quickly under the influence of alkalis. Heated with strong sulphuric acid, it is resolved into oxide of ethyl and acetic acid. Hydrochloric acid converts it into acetic acid and chloride of ethyl.

Action of Chlorine on *Acetate of Ethyl.* (Malaguti, Ann. Ch. Phys. [2] xx. 367; ibid. [3] xvi. 2, 68; Leblanc, ibid. [3] 197; Cloez, ibid. [3] xvii. 304.,— When acetate of ethyl is introduced into a bottle filled with dry chlorine gas, in the proportion of 1 atom acetate of ethyl to 8 atoms chlorine, and the action allowed to go on, first in the shade and afterwards with continually greater exposure to sunshine, a number of chlorinated compounds are formed in which 2, 3, 4, 5, 6, 7, and 8 atoms of hydrogen in the acetate of ethyl are successively replaced by an equal number of chlorine-atoms. It is however not always possible to obtain the particular compound required, the compounds $C^4H^6Cl^2O^2$, $C^4HCl^7O^2$, and $C^4Cl^8O^2$, being the only ones that can be produced with certainty. Other products are also formed, among which are acetic acid, trichloracetic acid, and sesquichloride of carbon. If the acetate of ethyl is at once exposed to sunshine in contact with chlorine, an explosion takes place, attended with deposition of charcoal.

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$$C^3H^4Cl^2O^2 + 2H^2O = CH^2O^2 + C^2H^4O^2 + 2HCl.$$

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$$C^3H^3Cl^3O^2 + 2K^2O = 2KCl + 2CHKO^2 + CHCl.$$

It is isomeric but not identical with trichloracetate of methyl, $C^2Cl^3O^2.CH^3$, produced by distilling wood-spirit with trichloracetic acid and a small quantity of sulphuric acid. (Laurent, Ann. Ch. Phys. [2] lxxiii. 25.)

Perchlorinated Acetate of Methyl, $C^3Cl^6O^2$. (Cloez, Ann. Ch. Phys. [3] xvii. 297, 311.)—This compound, which appears to be identical with perchlorinated formate of ethyl, is produced by exposing acetate of methyl to the action of chlorine in sunshine, as long as the gas continues to be absorbed. It is a colourless liquid, having a suffocating odour and a disagreeable taste, which soon becomes intolerably acid, from decomposition. Sp. gr. 1·705 at 18°. Boils at about 200°, with partial decomposition. It is quickly decomposed by water and by moist air, yielding hydrochloric, carbonic, and terchloracetic acids:

$$C^3Cl^6O^2 + 2H^2O = 3HCl + CO^2 + C^2HCl^3O^2.$$

Similarly by the fixed alkalis in solution. With aqueous ammonia, it forms trichloracetamide, together with chloride and carbonate of ammonium:

$$C^3Cl^6O^2 + 6NH^3 + 2H^2O = N.H^2.C^2Cl^3O + 3NH^4Cl + CO^3\,(NH^4).^2$$

With alcohol it forms hydrochloric acid, trichloracetate of ethyl, and monochlorinated formate of ethyl:

$$C^3Cl^6O^2 + 2C^2H^6O = 2HCl + C^2Cl^3O^2.C^2H^5 + CClO^2.C^2H^5.$$

Similarly with wood-spirit it yields trichloracetate of methyl, and monochlorinated formate of methyl.

The vapour passed through a red-hot porcelain tube is decomposed into chloraldehyde and chloro-carbonic oxide (phosgene) gas:

$$C^3Cl^6O^2 = C^2Cl^4O + COCl^2.$$

Acetate of Octyl, $C^2H^3O^2.C^8H^{17}$.—Prepared by passing hydrochloric acid gas through a mixture of acetic acid and octylic (caprylic) alcohol; or, better by distilling a mixture of octylic alcohol, acetate of sodium, and sulphuric acid. It is a liquid of very agreeable odour, insoluble in water, boiling at 190°. (Bouis, Compt. rend. xxxviii. 937.)

Acetate of Phenyl, $C^2H^3O^2.C^6H^5$.—Produced by the action of phosphate of phenyl on acetate of potassium: also by boiling an alcoholic solution of phosphate of phenyl with acetate of potassium. After all the alcohol has evaporated, the temperature of the mixture rises rapidly, and acetate of phenyl distils over in the form of an oily liquid. It is heavier than water, and slightly soluble in that liquid. Boils at 190°. Boiling potash decomposes it, yielding acetate of potassium and hydrate of phenyl. (Scrugham, Chem. Soc. Qu. J. vii. 241.)

Acetate of Tetryl, or Acetate of Butyl, $C^2H^3O^2.C^4H^9$.—Obtained by heating iodide of tetryl with a slight excess of very dry acetate of silver in a sealed flask at 100°:—also by distilling in an oil-bath equivalent quantities of acetate of potassium (recently fused) and tetryl-sulphate of potassium:

$$C^2H^3O^2.K + SO^4.K.C^4H^9 = C^2H^3O^2.C^4H^9 + SO^4.K^2$$

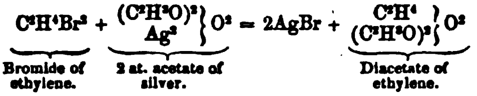
Acetate of Trityl, or Acetate of Propyl, $C^2H^3O^2.C^3H^7$.—Obtained by distilling propylic alcohol with a mixture of acetic and sulphuric acid. Resembles acetate of ethyl. Boils at 90°. (Berthelot.)

It is a colourless liquid of agreeable odour. Sp. gr. 0·8845 at 16° C. Boils at 114°. Vapour-density 4·073 (calculation, 4·017). Boiling potash converts it into acetate of potassium and tetrylic alcohol.

2. Diatomic Acetic Ethers. (*Glycolic Ethers.*)—These compounds are derived from the diatomic alcohols or glycols by the substitution of 1 or 2 at. acetyl ($C^2H^3O = Ac$), for 1 or 2 at hydrogen. They are related to the glycols in the same manner as the monatomic acetic ethers just described are related to the monatomic alcohols. The following have been obtained:—

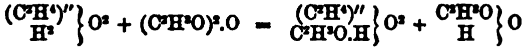
Monoacetate of Ethylene	$\left.\begin{matrix}(C^2H^4)''\\ Ac.H\end{matrix}\right\}O^2$	Diacetate of Butylene	$\left.\begin{matrix}(C^4H^8)''\\ Ac^2\end{matrix}\right\}O^2$
Diacetate of Ethylene	$\left.\begin{matrix}(C^2H^4)''\\ Ac^2\end{matrix}\right\}O^2$	Diacetate of Amylene	$\left.\begin{matrix}(C^5H^{10})''\\ Ac^2\end{matrix}\right\}O^2$
Diacetate of Propylene	$\left.\begin{matrix}(C^3H^6)''\\ Ac^2\end{matrix}\right\}O^2$	Diacetate of Benzylene	$\left.\begin{matrix}(C^7H^6)''\\ Ac^2\end{matrix}\right\}O^2$

The diacetates are produced by the action of acetate of silver on the chlorides, bromides, or iodides of the several diatomic alcohol-radicles: *e.g.*



$$\underbrace{C^2H^4Br^2}_{\text{Bromide of ethylene.}} + \underbrace{\left.\begin{matrix}(C^2H^3O)^2\\ Ag^2\end{matrix}\right\}O^2}_{\text{2 at. acetate of silver.}} = 2AgBr + \underbrace{\left.\begin{matrix}C^2H^4\\ (C^2H^3O)^2\end{matrix}\right\}O^2}_{\text{Diacetate of ethylene.}}$$

Monoacetate of ethylene is obtained by heating acetate of potassium with an alcoholic solution of bromide or chloride of ethylene, or by heating in a sealed tube a mixture of 1 at. hydrate of ethylene and 1 at. acetic anhydride:



$$\left.\begin{matrix}(C^2H^4)''\\ H^2\end{matrix}\right\}O^2 + (C^2H^3O)^2.O = \left.\begin{matrix}(C^2H^4)''\\ C^2H^3O.H\end{matrix}\right\}O^2 + \left.\begin{matrix}C^2H^3O\\ H\end{matrix}\right\}O$$

All these compounds when distilled with potash are converted into the corresponding diatomic alcohols. They will be more fully described in connection with these several alcohols.

3. Triatomic Acetic Ethers; Acetins. (Berthelot, Ann. Ch. Phys. [3] xli. 277; Gm. ix. 496; Gerh. iii. 950; Berthelot and De Luca, Ann. Ch. Phys. [3] liii. 433).—Compounds obtained by the union of 1 at. glycerin, $C^3H^8O^3$, with 1, 2, or 3 at. acetic acid $C^2H^4O^2$, with elimination of an equal number of atoms of water. They may be regarded as glycerin, $C^3H^5O^3.H^3$, in which 1, 2, or 3 at. hydrogen are replaced by acetyl.

Monoacetin, $C^5H^{10}O^4 = C^3H^5O^3.H^2.C^2H^3O$, is produced by heating a mixture of glycerin and glacial acetic acid to 100° for 24 hours. Slight traces are also formed by mere contact of the liquids at ordinary temperatures. It is a neutral liquid, having a slightly ethereal odour. Sp. gr. 1·20. Mixed with half its bulk of water, it forms a clear liquid, which becomes turbid on the addition of two or more volumes of water; but the acetin does not separate from it, and the emulsion continues opalescent even after the addition of a large quantity of water. Treated with alcohol and hydrochloric acid, it forms glycerin and acetate of ethyl. It mixes with ether.

Diacetin, also called *Acetidin*, $C^7H^{12}O^5 = C^3H^5O^3.H.(C^2H^3O)^2 = C^3H^8O^3 + 2C^2H^4O^2 - 2H^2O$, is obtained by heating glacial acetic acid with excess of glycerin to 200° for 3 hours; by heating the same two liquids together at 275°; by heating glycerin to 200° with acetic acid diluted with an equal bulk of water; and by heating to 200° a mixture of 1 pt. of glycerin with 4 or 5 pts. of acetic acid. It is a neutral odoriferous liquid having a sharp taste; sp. gr. about 1·85. Boils at 280°, and distils without alteration. Assumes a viscid consistency at −40°. It becomes slightly acid by prolonged contact with air. 100 pts. of it saponified with baryta, yield 52·4 pts. of glycerin and a quantity of acetate of barium corresponding to 66·4 pts. of acetic acid; calculation requires 52·3 glycerin and 68·2 acetic acid. With alcohol and hydrochloric acid it yields glycerin and acetate of ethyl. It dissolves in ether and in benzol.

Triacetin, $C^9H^{14}O^6 = C^3H^5O^3.(C^2H^3O)^3 = C^3H^8O^3 + 3C^2H^4O^2 - 3\,H^2O$. — Obtained by heating diacetin to 250° for 3 hours with 15 to 20 times its weight of glacial acetic acid. Resembles the preceding compound. Sp. gr. 1·174 at 8°. Volatilises without residue. 100 pts. saponified with baryta yielded 80·6 pts. acetic acid, and 43·1 glycerin; by calculation it should be 82·6 acetic acid and 42·2 glycerin. It is insoluble in water, but soluble in dilute alcohol.

A compound of acetic acid and glycerin, probably triacetin, appears to exist in cod-liver oil (De Jongh, Berz. Jahresber. 1843), and in considerable quantity in the oil obtained from the seeds of *Euonymus europæus* (Schweizer, J. pr. Chem. liii. 437). Acetic acid was also observed by Chevreul among the product of the saponification of fats.

Acetochlorhydrin, $C^5H^9ClO^3 = C^3H^8O^3 + C^2H^4O^2 + HCl - 2H^2O$, is obtained by passing hydrochloric acid gas to saturation into a mixture of acetic acid and glycerin heated to 100°, and saturating the liquid with carbonate of sodium, after leaving it at rest for several days. This process yields the compound mixed with dichlorhydrin. It is also obtained, together with the following compound, by the action of chloride of acetyl on glycerin. It is a neutral oil, smelling like acetate of ethyl and volatilising at about 250°.

Acetodichlorhydrin, $C^5H^8Cl^2O^2 = C^3H^8O^3 + C^2H^4O^2 + 2HCl - 3H^2O$, is obtained by adding chloride of acetyl to glycerin externally cooled, as long as any action takes place, distilling the product, and purifying the distillate obtained between 180° and 160°, by agitation with water and then with an alkali, drying with chloride of calcium and quicklime, and fractional rectification. It is a transparent neutral oil having a refreshing ethereal odour, sparingly soluble in water and distilling at 205° without decomposition. (Berthelot and De Luca.)

Diacetochlorhydrin, $C^7H^{11}ClO^4 = C^3H^8O^3 + 2C^2H^4O^2 + HCl - 3H^2O$, is obtained by the action of chloride of acetyl on a mixture of equal volumes of glycerin and glacial acetic acid. It is a neutral liquid which volatilises at 245°. (Berthelot and De Luca.)

Similar compounds are produced by the action of bromide of acetyl on glycerin. By treating glycerin with a mixture of chloride and bromide of acetyl in equal numbers of atoms, *acetochlorbromhydrin*, $C^5H^8ClBrO^2 = C^3H^8O^3 + C^2H^4O^2 + HCl + HBr - 3\,H^2O$, is obtained as a neutral colourless liquid, smelling like acetate of ethyl and bromide of ethylene, boiling at 208°, and distilling without decomposition. It is somewhat coloured by exposure to light. (Berthelot and De Luca.)

The formulæ of all these compounds may be derived from that of a triple molecule of water $\begin{array}{l}HHO\\HHO\\HHO\end{array}$. By replacing 3 at. hydrogen in this formula by the triatomic radicle, *glyceryl* C^3H^5, we obtain glycerin $\begin{array}{l}H\\H\\H\end{array}(C^3H^5)\begin{array}{l}O\\O\\O\end{array}$. Replacing 1, 2 or 3 at. H in this formula by acetyl ($C^2H^3O = Ac$), we obtain monoacetin, &c.; and, lastly, the replacement of one or two molecules of peroxide of hydrogen (HO), by chlorine in the formulæ of monoacetin and diacetin gives the acetochlorhydrins. Thus:

Monacetin	$\begin{array}{l}H\\Ac\\H\end{array}(C^3H^5)'''\begin{array}{l}O\\O\\O\end{array}$	Acetochlorbromhydrin .	$\begin{array}{l}\\Ac\\\end{array}(C^3H^5)'''\begin{array}{l}Br\\O\\Cl\end{array}$
Acetochlorhydrin . .	$\begin{array}{l}H\\Ac\\\end{array}(C^3H^5)'''\begin{array}{l}O\\O\\Cl\end{array}$	Diacetochlorhydrin . .	$\begin{array}{l}Ac\\Ac\\\end{array}(C^3H^5)'''\begin{array}{l}O\\O\\Cl\end{array}$
Acetodichlorhydrin . .	$\begin{array}{l}\\Ac\\\end{array}(C^3H^5)'''\begin{array}{l}Cl\\O\\Cl\end{array}$	Triacetin	$Ac^3(C^3H^5)'''O^3$.

ACETITE. A compound formed from acetic acid and mannite in the same manner as acetin from acetic acid and glycerin. (Berthelot, Compt. rend. xxxviii. 668.)

ACETOMETER. A hydrometer graduated for determining the strength of commercial acetic acid according to its density. (See ACETIC ACID.)

ACETONE. $C^3H^6O = C^2H^3O.CH^3 = CO(CH^3)^2$. *Pyroacetic spirit*, *Essiggeist*, *Brenzessiggeist* (Gm. ix. 1; xiii. 462; Gerh. i. 700; iii. 943; iv. 906).—This compound has long been known as a product of the destructive distillation of acetates (p. 28). It is also produced by passing the vapour of acetic acid through a red-hot tube; by heating gum, sugar, tartaric acid, citric acid and other vegetable substances in contact with lime; and by heating citric acid with permaganate of potassium, or with a mixture of binoxide of manganese and dilute sulphuric acid. (Péan de St. Gilles, Compt. rend. xlvii. 555.)

$$\underbrace{C^6H^8O^7}_{\text{Citric acid.}} + O = C^3H^6O + 3CO^2 + H^2O.$$

It is prepared: 1. By distilling acetate of barium or acetate of calcium at a moderate heat, the metal then remaining in the form of carbonate:

$$(C^2H^3O^2)^2Ba'' = C^3H^6O + CO^3Ba''.$$

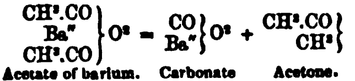
Acetate of barium when dry and pure, yields a perfectly colourless neutral distillate, in fact pure acetone. The calcium-salt requires a higher temperature to decompose it, and the distillate is in consequence contaminated with an empyreumatic oil, called *dumasin*, $C^{10}H^{16}O$.—2. By distilling in an iron retort or quicksilver bottle, a mixture of 2 pts. of acetate of lead and 1 pt. of pounded quicklime, rectifying the product several times over chloride of calcium, and finally distilling over the water-bath.

Acetone is a limpid, very mobile liquid, of sp. gr. 0·792 at 18° (Liebig), 0·814 at 0° (H. Kopp). It does not solidify at −15°. Boils at 56° (Dumas), at 56·3° (Kopp) under a pressure of 760 mm. Evaporates quickly, producing a considerable degree of cold. Vapour-density 2·0025 (Dumas). It has an agreeable odour, and a biting taste like that of peppermint. It is very inflammable, and burns with a white flame, without smoke.

Acetone mixes in all proportions with water, alcohol, ether, and many compound ethers. It does not dissolve potash or chloride of calcium. It dissolves many camphors, fats and resins.

Acetone forms definite compounds with the *alkaline bisulphites*. The potassium salt, $C^3H^6O + SO^3(KH)$, and the sodium-salt, $C^3H^6O + SO^3(NaH)$ crystallise in nacreous scales (Limpricht). The *ammonium-salt*, $C^3H^6O + SO^3(NH^4H,)$ is deposited on mixing an alcoholic solution of bisulphite of ammonium with acetone, in laminæ resembling cholesterin, which quickly aggregate into a heavy crystalline powder. (Städeler.)

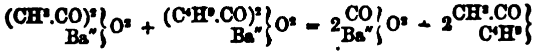
Acetone was regarded by Kane as an alcohol, $C^3H^5.H.O$, containing the radicle C^3H^5, which he called *mesityl*. According to this view, however, the oxidation of acetone should yield products containing C^3, just as the oxidation of common alcohol, C^2H^6O yields aldehyde and acetic acid containing C^2; but no such products are obtained. A more probable view of the composition of acetone is that of Chancel, who regards it as aldehyde coupled with methylene, $C^2H^4O.CH^2$, or, which comes to the same thing, that of Gerhardt and Williamson, who regard it as aldehyde in which the basic hydrogen is replaced by methyl; $\left.\begin{matrix}C^2H^3O\\ CH^3\end{matrix}\right\}$. This view is quite in accordance with the decomposition of acetates into acetone and carbonates. For acetyl may be regarded as a compound of methyl with carbonic oxide; [$C^2H^3O = CH^3.CO.$]; and it is easy to conceive that a molecule of acetate of barium, $\left.\begin{matrix}(CH^3.CO)^2\\ Ba''\end{matrix}\right\}O^2$, may decompose in such a manner that the CO of one of the acetyls may unite with the barium and the two external atoms of oxygen, to form carbonate of barium, while the methyl remains in combination with the other atom of acetyl, forming acetone:



$$\left.\begin{matrix}CH^3.CO\\ Ba''\\ CH^3.CO\end{matrix}\right\}O^2 = \left.\begin{matrix}CO\\ Ba''\end{matrix}\right\}O^2 + \left.\begin{matrix}CH^3.CO\\ CH^3\end{matrix}\right\}$$

Acetate of barium. Carbonate of barium. Acetone.

The same view is strengthened by the fact (discovered by Williamson) that when a mixture of acetate and valerate of barium is heated, an acetone is formed containing acetyl coupled with tetryl (C^4H^9), or valyl (C^5H^9O) with methyl: thus



$$\left.\begin{matrix}(CH^3.CO)^2\\ Ba''\end{matrix}\right\}O^2 + \left.\begin{matrix}(C^4H^9.CO)^2\\ Ba''\end{matrix}\right\}O^2 = 2\left.\begin{matrix}CO\\ Ba''\end{matrix}\right\}O^2 + 2\left.\begin{matrix}CH^3.CO\\ C^4H^9\end{matrix}\right\}$$

Decompositions of Acetone.—1. Acetone passed in the state of vapour through a red-hot tube, deposits charcoal and is converted into a peculiar oil called *dumasin*, which generally passes over together with acetone in the distillation of acetates.

2. Acetone is decomposed by *chlorine*, a portion of its hydrogen being replaced by that element; but it is not possible in this manner to replace the whole of the hydrogen by chlorine; even a mixture of chlorate of potassium and hydrochloric acid does not appear to be capable of replacing more than two of the hydrogen atoms by chlorine. The higher chlorinated acetones, may however be obtained by the action of chlorine, or the mixture just mentioned, on other organic bodies. (See CHLORACETONES, p. 29.)

Chlorine, in presence of alkalis, converts acetone into chloroform:

$$C^3H^6O + 12\,Cl + H^2O = 2CHCl^3 + CO^2 + 6\,HCl.$$

Bromine, in presence of alkalis, acts in a similar manner, producing bromoform: but iodine forms only a dark pitchy mass.

4. *Hydrochloric acid gas* is absorbed in large quantity by acetone, and according to Kane, yields chloride of mesityl (or chloropropylene) C^3H^5Cl. *Hydriodic acid gas* passed into acetone forms, according to Kane, iodide of mesityl, C^3H^5I, which distils over with the hydriodic acid; iodide of pteleyl C^3H^3I (or rather tri-iodomesitylene, $C^9H^9I^3$), which remains suspended in the residual liquid, in the form of yellow scales; and mesityl-hypophosphorous acid, $C^3H^6O.PHO$, which separates in silky needles as the liquid cools. Friedel (Compt. rend. xlv. 1013) stated that a solution of hydrochloric acid gas in acetone yielded, when heated to 100°, acetic acid and chloride of methyl ($2C^3H^6O + 4HCl = C^2H^4O^2 + 4CH^3Cl$), and similarly with hydriodic acid; but he has since admitted that these results were obtained with impure acetone containing wood-spirit.

5. With *pentachloride of phosphorus*, acetone yields chloropropylene, C^3H^5Cl, boiling at about 30° and *methylchloracetol*, a compound isomeric with chloride of propylene, $C^3H^6Cl^2$. This body treated with silver-salts, ammonia, ethylate of sodium, or alcoholic potash, is resolved into hydrochloric acid and chloropropylene, identical with the body obtained by the action of alcoholic potash on $C^3H^6Cl^2$. Hence it appears that acetone is related to the propylene series. (Friedel, Ann. Ch. Pharm. cxii. 236.)

6. Strong *nitric acid* acts violently on acetone, giving off copious red fumes, and forming mesitic aldehyde, C^3H^4O, and nitrite of pteleyl, $C^3H^3NO^2$. [or rather trinitromesitylene, $C^9H^9(NO^2)^3$], together with oxalic and cyanuric acid (Kane). By dropping acetone into fuming nitric acid contained in a flask externally cooled, and adding water as soon as the action ceases, a heavy oil is obtained, which explodes with violence when heated, giving off red fumes. (Fittig, Ann. Ch. Pharm. cx. 45.)

7. Acetone mixed with strong *sulphuric acid* becomes heated, and, according to the quantity of acid present and the rise of temperature which takes place, forms either

oxide of mesityl, $C^6H^{10}O$, or mesitylene, C^9H^{12}, together with mesitylsulphuric acid, $SO^4.C^3H^5.H$, and sulphurous acid. (According to Kane, the composition of mesitylsulphuric acid is $C^6H^5O.HO.SO^3$, and there is formed at the same time another acid called *permesitylsulphuric* acid, $C^6H^5O^2.\,2\,SO^4H$).

8. Glacial *phosphoric* acid forms with acetone a dark brown mass, partly consisting of mesitylphosphoric acid. (Kane.)

9. A solution of *phosphorus* in acetone turns acid when kept for some weeks, and more quickly when heated, even in perfectly air-tight vessels. According to Zeise, the change consists in the formation of three peculiar acids, to which he gives the names, *phosphacetic*, *acephosgenic* and *acephoric* acids; but their nature and composition have not been clearly made out. Products of like nature are obtained with *sulphur*. *Sulphide of phosphorus* forms with acetone a peculiar acid, and an oil which has a powerful odour but no acid reaction. (Zeise.)

10. A solution of *ammonia* in acetone yields, by spontaneous evaporation, a colourless syrupy residue, which gradually changes into an alkaline liquid, consisting of *acetonine*, $C^9H^{18}N^2$, an organic base, which bears to acetone the same relation that amarine bears to bitter-almond oil:

$$3C^3H^6O + 2\,NH^3 = C^9H^{18}N^2 + 3H^2O.$$

The non-basic compound first formed is perhaps isomeric with acetonine. (Städeler, Chem. Gaz. 1853, 241.)

11. By the action of *ammonia* and *sulphur* on acetone, Zeise obtained a number of products, which however do not present any definite characters. (Gm. ix. 11.)

12. By the simultaneous action of *ammonia* and *hydrosulphuric acid*, acetone is converted into *thiacetonine*, a sulphuretted base consisting probably of $C^9H^{17}NS^2$. It crystallises in shining yellowish rhombohedrons, having an alkaline reaction, sparingly soluble in water, but dissolving with facility in alcohol, ether, acetone, and dilute acids. (Städeler.)

13. When 1 volume of acetone is mixed with 1 vol. *disulphide of carbon* and 2 vols. aqueous *ammonia*, laminated crystals, resembling ice, form in the liquid after a few days; but these gradually disappear, and are succeeded by large yellow crystals, which are insoluble in water, sparingly soluble in ether, but dissolve, with decomposition, in warm alcohol and in boiling hydrochloric acid (Hlasiwetz, J. pr. Chem. li. 355). Hlasiwetz assigns to these crystals the improbable formula $C^{30}H^{52}N^4S^9$. Städeler, on the other hand, regards them as the hydrosulphate of an organic base, *carbothiacetonine*, $C^{10}H^{18}N^2S^2$, and represents their formation by the equation,

$$3\,C^3H^6O + 2NH^3 + CS^2 = C^{10}H^{18}N^2S^2 + 3H^2O.$$

The formula $C^{10}H^{18}N^2S^2.H^2S$ agrees pretty nearly with the analytical numbers obtained by Hlasiwetz. A cold alcoholic solution of the crystals forms with dichloride of platinum a brownish yellow, amorphous precipitate consisting of $C^{10}H^{18}N^2S^2.PtCl^2.PtS$, and with mercuric chloride a white precipitate, which, according to Städeler, is merely Hg^2Cl^2S mixed with a small quantity of hydrochlorate of carbothiacetonine.

14. Acetone heated with a mixture of *hydrocyanic* and *hydrochloric acid*, is converted into *acetonic acid*, $C^4H^8O^3$ (Städeler):

$$C^3H^6O + CNH + 2\,H^2O = C^4H^8O^3 + NH^3.$$

15. Acetone distilled with *acid chromate of potassium* and *sulphuric acid* gives off acetic and carbonic acids, but no formic acid:

$$C^3H^6O + 4O = C^2H^4O^2 + CO^2 + H^2O.$$

16. Caustic alkalis, such as *hydrate of potassium* and *quick lime*, exert a dehydrating action on acetone, several products being formed, according to the proportion of water abstracted. Löwig and Weidmann, by subjecting acetone to the action of hydrate of potassium, obtained a dark brown mass, consisting chiefly of *xylite-oil*, $C^{12}H^{18}O$, which boiled at 200°, together with a resin which they call *xylite-resin*. Völckel, by leaving acetone for some time in contact with quick lime, also obtained an oil boiling above 200°, which he regarded as xylite-oil. But, according to Fittig (Ann. Ch. Pharm. cx. 32), the products obtained by the action of quick lime in closed vessels, are oxide of mesityl, $C^6H^{10}O^2$, boiling at 131°, and a liquid isomeric or identical with *phorone*, $C^9H^{14}O$. It must also be noticed that Schweizer and Weidmann (J. pr. Chem. xxiii. 14) obtained xylite-oil, and likewise xylite-naphtha, $C^{12}H^{22}O^3$, by the action of potash and of strong sulphuric acid on a compound produced from crude wood-spirit, which those chemists called *xylite*, assigning to it the improbable formula $C^8H^8O^{2\frac{1}{2}}$, but which was probably nothing but somewhat impure acetone. On the whole it appears that the action of alkalis on acetone is similar to that of sulphuric acid (p. 52), consisting in an abstraction of the elements of water. The products

obtained by the action of these dehydrating agents on acetone may be arranged as follows, according to their boiling-points:

		Boiling-point.
Xylite-naphtha	$C^{12}H^{22}O^3 = 4C^3H^6O - H^2O$	110° to 120°
Oxide of Mesityl	$C^6H^{10}O = 2C^3H^6O - H^2O$	„ 131°
Mesitylene	$C^9H^{12} = 3C^3H^6O - 3H^2O$	155° „ 160°
Phorone?	$C^9H^{14}O = 3C^3H^6O - 2H^2O$	210° „ 220°
Xylite-oil	$C^{12}H^{18}O = 4C^3H^6O - 3H^2O$	above 200°

Vapour of acetone passed over heated hydrate of potassium or potash-lime is resolved into marsh-gas and carbonic anhydride:

$$C^3H^6O + 2KHO = CO^3K^2 + 2CH^4;$$

or if the heat is not very strong, the chief products are acetic acid, formic acid and hydrogen:

$$C^3H^6O + 2KHO + H^2O = C^2H^3KO^2 + CHKO^2 + 6H.$$

17. *Sodium* is violently attacked by anhydrous acetone, but without evolution of hydrogen, and hydrate of sodium is separated in white flakes. The liquid gradually assumes a pasty consistence, and the sodium becomes coated with oxide, so that it no longer acts perceptibly on the acetone. On distilling the mass, undecomposed acetone passes over first, and afterwards a watery liquid collects in the receiver, covered with a yellowish oil. On pouring the distillate into a basin, so that the undecomposed acetone may evaporate, the watery layer solidifies in a white crystalline mass, from which the oil may be separated by pressure between paper. The crystals consist of *hydrate of pinacone*, $C^6H^{12}O + 7H^2O$, and the oily liquid is *phorone*, $C^9H^{14}O$. The pinacone is produced by the abstraction of 1 at. oxygen from a double molecule of acetone:

$$2C^3H^6O + 2Na = Na^2O + C^6H^{12}O;$$

and the anhydrous pinacone thus formed appears to take water from another portion of the acetone, converting it into phorone:

$$3C^3H^6O - 2H^2O = C^9H^{14}O.$$

By heating the crystals of hydrated pinacone in a narrow glass tube, a viscid liquid is obtained, which absorbs water rapidly from the air, and is reconverted into the crystalline hydrate. This liquid appears to be anhydrous pinacone; but it is difficult to expel all the water (Städeler, Ann. Ch. Pharm. cxi. 277). Fittig (ibid. cx. 23) assigns to the hydrated crystals, the formula $C^3H^6O + 3H^2O$, regarding them as the hydrate of *paracetone*, a compound isomeric with acetone, which he also states is obtained in anhydrous crystals, by the action of ammonia on acetone. Fittig's formulæ do not, however, agree with the results of analysis so well as Städeler's (see PINACONE); moreover it is very unlikely that sodium should act with violence on acetone, without abstracting a portion of its oxygen. The action of ammonia on acetone, produces, according to Städeler, not a crystalline compound, but a liquid organic base, acetonine (p. 32).

18. Dry *tetrachloride of platinum* dissolves in acetone, with evolution of heat, and forms a brown solution, which, when evaporated, gives off hydrochloric acid, and leaves a resinous mass, containing among other products a yellow crystalline substance called *acechloride of platinum* or *chloroplatinite of mesityl*, $C^6H^{10}O.PtCl^2$.(?) This compound may be obtained in larger quantity, by triturating tetrachloride of platinum with acetone to the consistence of a thick paste, leaving the mass in a close vessel till it liquefies and ultimately forms crystals, washing these crystals with acetone, and purifying them by crystallisation from boiling acetone. Acechloride of platinum thus obtained is yellow, inodorous, sparingly soluble in water, alcohol and ether, more readily in aqueous chloride of potassium or sodium. Cold acetone dissolves $\frac{1}{30}$ of it; boiling acetone a little more. The aqueous solution reddens litmus. The compound is decomposed and dissolved by potash, forming a brown solution. When boiled with water, it deposits a black substance called *aceplatinous oxide*, probably C^3PtO. The same substance is deposited on boiling the mother-liquor of acichloride of platinum. The acichloride yields by distillation a residue of carbide of platinum, PtC. (Zeise, Ann. Ch. Pharm. xxxiii. 29; Gm. ix. 31.)

SUBSTITUTION-PRODUCTS OF ACETONE. *Chloracetones.*—Each of the atoms of hydrogen in acetone may be replaced by chlorine, giving rise to six chlorinated acetones. The first of these compounds is obtained by the action of nascent chlorine on acetone; the second by that of chlorine or the oxides of chlorine on acetone; the third and fourth by the action of chlorine on crude wood-spirit, probably containing acetone; the fifth and sixth can only be obtained by the action of chlorine or the oxides of chlorine on other organic compounds.

Monochloracetone, C^3H^5ClO, is obtained by the action of a feeble electric current (from three Bunsen's cells) on a mixture of acetone and hydrochloric acid, the chlorine set free at the positive pole from the hydrochloric acid, acting on the acetone and taking the place of 1 at. hydrogen. It is an oily, colourless liquid, which, when separated from the watery solution and rectified, boils at 117°, has a sp. gr. of 1·14 at 14°, and vapour-density = 3·40. Its vapour acts strongly on the nose and eyes, producing a copious flow of tears. (Riche, Compt. rend. xlix. 176.)

Dichloracetone, $C^3H^4Cl^2O$ (Kane's *mesitic chloral*), is produced by passing dry chlorine into anhydrous acetone, or better, according to Städeler, by mixing acetone in a capacious flask with twice its volume of strong hydrochloric acid diluted with an equal bulk of water, and adding pulverized chlorate of potassium by small portions. It is an oily liquid of sp. gr. 1·331 (Kane); 1·236 at 90° (Fittig). Boils at 116·5° (Städeler); at 121°·5 (Fittig). Vapour-density 3·2. Its vapour smells like chloroform at first, but, after a few seconds, attacks the nose and eyes with violence. The liquid blisters the skin like cantharides, producing wounds which are difficult to heal (Liebig, Kane, Fittig.) It is insoluble in water, but mixes in all proportions with alcohol and ether.

Trichloracetone, $C^3H^3Cl^3O$, is obtained by the action of chlorine on wood-spirit. When chlorine gas is passed into ordinary (unpurified) wood-spirit, crystals are formed consisting of $C^6H^{10}Cl^2O^2$ (*chloromesitate of methylene*), but if the action of the chlorine be further continued, the crystals disappear, and an oily liquid is formed, which is terchlorinated acetone. It is heavier than water, has an extremely pungent odour, and cannot be distilled without decomposition. (Bouis.)

Tetrachloracetone, $C^3H^2Cl^4O$, is obtained by dissolving the crystals just mentioned in wood-spirit and passing chlorine through the solution. It is an oily very volatile and pungent liquid, which blisters the skin. When exposed to moist air, it forms crystals containing $C^3H^2Cl^4O + 4H^2O$, which melt at 35°, and dissolve in water, alcohol and ether, forming solutions which are not precipitated by nitrate of silver. The crystals distilled with phosphoric anhydride yield the original anhydrous compound. This and the preceding compound are doubtless formed from acetone contained in the wood-spirit. (Bouis, Ann. Ch. Phys. [3] xxi. 111.)

Pentachloracetone, C^3HCl^5O, is obtained by the action of a mixture of chlorate of potassium and hydrochloric acid on several organic compounds, viz. kinic, citric, gallic, pyrogallic, catechucic and salicylic acids, also kinone, muscular flesh, albumin, indigo and tyrosin. The best mode of preparing it is to add a considerable quantity of chlorate of potassium to a boiling solution of kinic acid, and then add strong hydrochloric acid in such portions that chlorine and chlorous acid may be continually evolved. The distillate is concentrated by rectification over chloride of calcium. It then, if tolerably pure, solidifies into a crystalline hydrate when covered with water at 4° or 5°. If no solidification takes place, the product is contaminated with other oils, and must be purified by agitating it with ice-cold water, and heating the decanted and clarified liquid to 60°; the greater part of the oily impurities then separate out. To purify it completely, it is converted into the crystalline hydrate as above mentioned, and the crystals are pressed between paper. The pure anhydrous compound may be obtained by melting the crystals in a glass tube, whereupon they separate into a watery and an oily liquid, the latter, which is undermost, being pure anhydrous pentachloracetone. It is a colourless rather mobile oil, having a burning aromatic taste, and an odour like that of chloral. Sp. gr. between 1·6 and 1·7. It remains liquid at −20° and boils at 190°. The hydrate, which crystallises in rhombic tables, contains 4 atoms of water. Water dissolves $\frac{1}{10}$ of its volume of anhydrous pentachloracetone, and on the other hand, this compound takes up a certain quantity of water without change of appearance; but it then becomes turbid at the heat of the hand, like hydrated conine. Pentachloracetone dissolves readily in alcohol and ether. The alcoholic solution mixed with alcoholic potash deposits chloride of potassium together with scaly crystals, probably consisting of *dichloracetate* of *potassium*, and the solution is found to contain formic acid:

$$C^3HCl^5O + H^2O = \underbrace{CHCl^3}_{\text{Chloroform.}} + \underbrace{C^2H^2Cl^2O^2}_{\text{Dichloracetic acid.}}$$

and:

$$CHCl^3 + 2H^2O = 3HCl + CH^2O^2.$$

(Städeler, Ann. Ch. Pharm. cxi. 277.)

Hexachloracetone, C^3Cl^6O (discovered by Plantamour, who assigned to it the formula ($C^8Cl^{16}O^3$), is obtained by the action of chlorine in sunshine on an aqueous solution of citric acid. It is an oily liquid of peculiar pungent odour, sp. gr. 1·75 at 10°, and boiling between 200° and 201°. It makes transient grease spots upon paper, gradually reddens litmus paper, and forms with water, at temperatures not above 6°, a crystalline hydrate, $C^3Cl^6O + H^2O$, which melts at a temperature above 15°, with separation of an oil.

Bromacetone, C^3H^5BrO, is produced similarly to monochloracetone, viz. by the action of a feeble electric current on a mixture of acetone and hydrobromic acid. It is colourless when first prepared, but turns brown in a few minutes, and is decomposed by distillation, the greater portion however passing over between 140° and 145°. Its vapour irritates the eyes so strongly that the spilling of a few drops renders the air of a room unendurable. (Riche.)

Iodacetone appears also to be formed in small quantity by the electrolysis of a mixture of acetone and hydriodic acid. (Riche.)

Methylacetone, $C^4H^8O = C^3H^5(CH^3)O$. — When crude commercial acetone, or, better, the brown liquid which floats on the top of it, is dehydrated with chloride of calcium and then subjected to fractional distillation, pure acetone passes over below 60° and the distillate which is obtained between 60° and 130°, yields, after about thirty fractionations, three distinct compounds, viz. methylacetone, boiling between 75° and 77°, ethylacetone, $C^5H^{10}O$, between 90°, and 95° and dumasin, $C^6H^{10}O$, between 120° and 125°. (Fittig, Ann. Ch. Pharm. cx. 18.)

Methylacetone is a colourless liquid of sp. gr. 0·838 at 19° C. having the odour of acetone, miscible in all proportions with water and alcohol. It combines with acid sulphite of sodium, forming a crystalline compound, $2C^4H^7NaSO^3 + 3H^2O$, which is very soluble in water.

Ethylacetone, $C^5H^{10}O = C^3H^5(C^2H^5)O$.—Transparent, colourless liquid, smelling faintly like acetone, sparingly soluble in water, but miscible in all proportions with alcohol, sp. gr. 0·842 at 19°. Boils between 90° and 95°. With acid sulphite of sodium it forms the compound $2C^5H^9NaSO^3 + 3H^2O$, which crystallises in colourless nacreous laminæ very soluble in water. (Fittig.)

ACETONES or **KETONES.** This term is applied to a class of compounds which, like that just described, are composed of an acid-radicle united with an alcohol-radicle. Nearly all the acetones at present known consist of the radicle of a fatty acid combined with one of the corresponding alcohol-radicles; their general formula being $C^mH^{2m+1}.C^nH^{2n-1}O$. where m may be either greater or less than n. When $m = 0$, the acetone becomes an aldehyde, $H.C^nH^{2n-1}O = C^nH^{2n}O$; the acetones may therefore be regarded as aldehydes in which 1 at. hydrogen is replaced by an alcohol-radicle.

Acetones are either *simple* or *compound*. In the simple acetones, $m = n - 1$, so that their general formula is $C^{n-1}H^{2n-1}.C^nH^{2n-1}O. = C^{2n-1}H^{4n-2}O$; thus, acetic acetone, for which $n = 2$, is $CH^3.C^2H^3O$. The simple acetones are produced by heating the barium or calcium salts of the fatty acids, a molecule of the salt being decomposed in such a manner that one atom of its acid radicle is resolved into the next lowest alcohol-radicle and carbonyl (CO), so that a carbonate of calcium or barium is formed at the same time:

$$\left.\begin{matrix}(CO.C^{n-1}H^{2n-1})^2\\ Ca''\end{matrix}\right\}O^2 = \left.\begin{matrix}C^nH^{2n-1}O\\ C^{n-1}H^{2n-1}\end{matrix}\right\} + \left.\begin{matrix}CO\\ Ca''\end{matrix}\right\}O^2.$$

The formation of acetic acetone or methyl-acetyl (p. 26) by the decomposition of acetate of barium, is a particular example of this process. In like manner, *propione* or *ethyl-propionyl*, $C^2H^5.C^3H^5O$, *butyrone* or *trityl-butyryl*, $C^3H^7.C^4H^7O$, *valerone* or *tetryl-valyl*, $C^4H^9.C^5H^9O$, are produced by the decomposition of the propionates, butyrates valerates, &c.

These simple acetones were the only ones known, till Williamson in 1851 (Chem. Soc. Qu. J. iv. 238) showed that, by distilling a mixture of the barium or calcium salts of two different fatty acids, acetones may be obtained in which an acid radicle is associated with an alcohol-radicle which is not the next below it in the series [m greater or less than $n - 1$]: these are the so-called compound or intermediate acetones. If the acids whose salts are distilled together contain p and q atoms of carbon, the decomposition may be represented by the equation:

$$\left.\begin{matrix}(C^pH^{2p-1}O)^2\\ Ca''\end{matrix}\right\}O^2 + \left.\begin{matrix}(CO.C^{q-1}H^{2q-1})^2\\ Ca''\end{matrix}\right\}O^2 = 2\left.\begin{matrix}C^pH^{2p-1}O\\ C^{q-1}H^{2q-1}\end{matrix}\right\} + 2\left.\begin{matrix}CO\\ Ca''\end{matrix}\right\}O^2;$$

or, since it is indifferent which of the acid radicles we suppose to be decomposed, the formula of the acetone thus produced may also be $\left.\begin{matrix}C^qH^{2q-1}O\\ C^{p-1}H^{2p-1}\end{matrix}\right\}$. Thus a mixture of acetate and valerate of calcium yields by distillation either *methyl-valyl*, $CH^3.C^5H^9O$, or *tetryl-acetyl*, $C^4H^9.C^2H^3O$, either of these formulæ being equal to $C^6H^{12}O$. Possibly two isomeric compounds having these formulæ may be produced together. If one of the mixed salts is a formate, $\left.\begin{matrix}(CO.H)^2\\ Ca''\end{matrix}\right\}O^2$, the alcohol-radicle separated from it is reduced to an atom of hydrogen, and the acetone becomes an aldehyde. (See ALDEHYDES.)

The compound acetones are also produced, together with the simple acetones and other products, when a calcium or barium salt of a fatty acid is distilled alone. Thus the distillation of butyrate of calcium yields, besides butyrone and a small quantity of butyral, a considerable number of hydrocarbons (Berthelot, Compt. rend. xliii. 236); and among these, methyl and ethyl appear to occur, and give rise to the formation of *ethyl-butyryl*, $C^2H^5.C^4H^7O$, and *methyl-butyryl*, $CH^3.C^4H^7O$. (Friedel, Compt. rend. xlvii. 553.)

The following is a list of the acetones, or ketones, at present known, which are derived from the fatty acids:

Methyl-acetyl (Acetone)	$C^3H^6O = CH^3.C^2H^3O$
Methyl-butyryl	$C^5H^{10}O = CH^3.C^4H^7O$
Ethyl-propionyl (Propione) . . .	$C^5H^{10}O = C^2H^5.C^3H^5O$
Ethyl-butyryl	$C^6H^{12}O = C^2H^5.C^4H^7O$
Methyl-valyl	$C^6H^{12}O = CH^3.C^5H^9O$
Trityl-butyryl (Butyrone)	$C^7H^{14}O = C^3H^7.C^4H^7O$
Methyl-œnanthyl	$C^8H^{16}O = CH^3.C^7H^{13}O$
Tetryl-valyl (Valerone)	$C^9H^{18}O = C^4H^9.C^5H^9O$
Amyl-capronyl (Capronone) . . .	$C^{11}H^{22}O = C^5H^{11}.C^6H^{11}O$
Heptyl-capryl (Caprylone) . . .	$C^{15}H^{30}O = C^7H^{15}.C^8H^{15}O$
Octyl-pelargonyl (Pelargonone) . .	$C^{17}H^{34}O = C^8H^{17}.C^9H^{17}O$
Laurone	$C^{23}H^{46}O = C^{11}H^{23}.C^{12}H^{23}O$
Myristone	$C^{27}H^{54}C = C^{13}H^{27}.C^{14}H^{27}O$
Palmitone or Margarone	$C^{31}H^{62}O = C^{15}H^{31}.C^{16}H^{31}O$
Stearone	$C^{35}H^{70}O = C^{17}H^{35}.C^{18}H^{35}O$

Some of the compounds in this table are isomeric, *e. g.* propione and butyracetone. Among the higher terms of the series, the number of such isomeric compounds is doubtless very great, though but few of them have yet been obtained.

These bodies, with the exception of acetic acetone, have not been much studied. Their reactions, so far as they are known, resemble those of common acetone already described. The lower terms of the series unite with the acid sulphites of the alkali-metals, generally forming crystalline compounds. The best mode of purifying the acetones is to shake them up with a strong aqueous solution of acid sulphite of potassium or sodium, and distil the resulting solid compound with potash. The acetone then passes over pure.

But little is known respecting acetones belonging to other series of acids. Two have been formed containing the radicle benzoyl, viz. *benzophenone*, or *phenyl-benzoyl*, $C^{13}H^{10}O = C^6H^5.C^7H^5O$, the acetone of benzoic acid, obtained by heating benzoate of potassium; and *methyl-benzoyl*, $C^8H^8O = CH^3.C^7H^5O$, obtained by distilling together equivalent quantities of acetate and benzoate of calcium (Friedel). Benzophenone treated with nitric acid yields *nitrobenzophenone*, $C^{13}H^8(NO^2)^2O$.

The calcium-salt of camphoric acid, which is dibasic, yields by dry distillation an oily liquid called *phorone*, which has the constitution of an acetone:

$$\underbrace{\left.\begin{matrix}C^{10}H^{14}O^2\\ Ca''\end{matrix}\right\}}_{\text{Camphorate of calcium.}} O^2 = \underbrace{C^9H^{14}O}_{\text{Phorone.}} + \underbrace{\left.\begin{matrix}CO\\ Ca''\end{matrix}\right\}}_{\text{Carbonate of calcium.}} O^2;$$

and suberate of calcium, $C^8H^{12}O^4Ca$, yields in like manner *suberone*, $C^7H^{12}O$, mixed with other products. These are the only two acetones of dibasic acids yet discovered. (Gerhardt, Traité, iv. 640.)

ACETONINE. $C^9H^{18}N^2$.—Produced by the action of ammonia on acetone (p. 28), either when a solution of ammonia in acetone is left to evaporate spontaneously to a syrup, or when acetone saturated with ammonia is heated to 100° in a sealed tube. It is a colourless liquid, having a peculiar urinous odour, a burning taste and alkaline reaction, easily soluble in water, alcohol, and ether. It unites with acids, forming salts. The *oxalate* $C^9H^{18}N^2.C^2H^2O^4 + H^2O$ crystallises from a hot saturated alcoholic solution in delicate colourless prisms, which are soluble in water, insoluble in ether, give off half their water at 100°, the rest between 115° and 120°, and decompose at a higher temperature. The *chloroplatinate*, $2(C^9H^{18}N^2.HCl).PtCl^4$, forms lustrous, orange-coloured, four-sided prisms with oblique terminal faces. It is soluble in water, also in boiling alcohol containing hydrochloric acid; insoluble in ether. (Städeler, Ann. Ch. Pharm. cxi. 308.)

ACETONITRILE. C^2H^3N.—A compound obtained by treating acetate of ammonium or acetamide with phosphoric anhydride:

$$\underbrace{C^2H^3O^2.NH^4}_{\text{Acetate of ammonium.}} - 2H^2O = C^2H^3N;\ \text{and}\ \underbrace{C^2H^5NO}_{\text{Acetamide.}} - H^2O = C^2H^3N.$$

It is identical with cyanide of methyl, obtained by distilling cyanide of potassium with methylsulphate of potassium. (See CYANIDE OF METHYL.)

Chloracetonitrile, C^2Cl^3N, or cyanide of trichloromethyl, $CCl^3.CN$, is obtained by distilling trichloracetate of ammonium or trichloracetamide with phosphoric anhydride. It is a liquid boiling at 81°; of sp. gr. 1·4441. With boiling potash, it yields ammonia and trichloracetate of potassium. It is violently attacked by potassium.

ACETONYL. C^6H^{12}.—A hypothetical radicle supposed by Hlasiwetz to exist in the yellow crystals formed by the action of ammonia and bisulphide of carbon on acetone. Hlasiwetz assigns to these crystals the formula $C^{32}H^{56}N^8S^9$, and regards them as *sulphocyanate of acetonyl with sulphocarbonate of sulphacetonyl* = $2(C^6H^{12}.2CNS) + 2\,C^6H^{12}S.C^2H^4N^2S^3$. Städeler's view of the constitution of this compound (p. 52), is much more probable.

ACETOSYL. The name given by Gerhardt to the hypothetical radicle C^2H^3 or C^4H^3, originally called *acetyl*, and supposed by some chemists to exist in acetic acid and its derivatives. (See ACETYL and VINYL.)

ACETOXYL. Kolbe's name for the radicle C^2H^3O or $C^4H^3O^2$, usually called acetyl, which see.

ACETUREÏD. Syn. of Acetyl-urea.

ACETYL. C^2H^3O or $C^4H^3O^2$. *Acetoxyl, Othyl.*—A radicle not yet isolated, but supposed to exist in acetic acid and its derivatives, the rational formula of acetic acid being, on this hypothesis, $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O$, and that of acetic anhydride, $\left.\begin{matrix}C^2H^3O\\C^2H^3O\end{matrix}\right\}O$.

The reason for assuming the existence of this radicle in the acetic compounds is, that the formula to which it leads, affords the simplest representation of the most important reactions of acetic acid and the other bodies of the series. Thus, when acetic acid $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O$ is treated with a metallic oxide or hydrate, the basic atom of hydrogen is replaced by a metal, and an acetate of that metal $\left.\begin{matrix}C^2H^3O\\M\end{matrix}\right\}O$ is produced. On treating the same compound with pentasulphide of phosphorus, P^2S^5, the external atom of oxygen is replaced by sulphur, and thiacetic acid, $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}S$ is formed; and by the action of pentachloride of phosphorus, the group HO is replaced by Cl, and chloride of acetyl $C^2H^3O.Cl$ is produced. (See ACETIC ACID, and ACIDS, p. 44.)

Formerly, however, acetic acid, and the other members of the same group, were supposed to be derived from the radicle C^2H^3 or C^4H^3; and to this the name *acetyl* was originally applied. Thus, anhydrous acetic acid was regarded as a trioxide of this radicle, viz. $C^4H^3.O^3$, and the hydrated acid as a compound of this oxide with water, viz. $C^4H^3O^3.HO$. &c. To apply the same name to two different radicles would of course create confusion; hence the terms *acetoxyl* proposed by Kolbe, and *othyl* (abbreviation of oxygen-ethyl) by Williamson, for the radicle C^2H^3O. Most chemists, however, are of opinion, that the radicle supposed to exist in acetic acid and its derivatives, is most appropriately designated by the term *acetyl*; and accordingly, this term is now generally applied to the group C^2H^3O, while C^2H^3, which more properly belongs to another series of compounds derived from alcohol, ether and ethylene, and having a less intimate distant relation to acetic acid, is called by a different name. (See ACETOSYL and VINYL.)

Acetyl, C^2H^3O is regarded by Kolbe as a compound or conjugate radicle, containing methyl and carbonyl, viz. CH^3,CO; and in like manner, propionyl, C^3H^5O, is regarded as a compound of ethyl: $C^2H^5.CO$; butyryl, C^4H^7O, as a compound of trityl: $C^3H^7.CO$, &c. each radicle of a fatty acid being supposed to contain the next lowest alcohol-radicle associated with carbonyl. This view, which has been adopted by Gerhardt, in his "Traité de Chimie Organique" is based upon the fact that certain methyl-compounds may be obtained from acetic acid and its derivatives, and the contrary; similar transformations likewise taking place in the other terms of the series. Thus, a solution of acetate of potassium subjected to electrolysis, yields methyl and carbonic anhydride:

$$\underbrace{\left.\begin{matrix}CH^3.CO\\H\end{matrix}\right\}O}_{\text{Acetic acid.}} = \underbrace{CH^3}_{\text{Methyl.}} + CO^2 + H$$

Cyanide of methyl boiled with aqueous potash gives off ammonia and forms acetate of potassium:

$$\underbrace{CH^3.CN}_{\text{Cyanide of methyl}} + KHO + H^2O = \underbrace{\left.\begin{matrix}CH^3.CO\\K\end{matrix}\right\}O}_{\text{Acetate of potassium.}} + NH^3;$$

and acetate of ammonium $(CH^3.CO).NH^4.O$, treated with phosphoric anhydride, gives off $2H^2O$, and is reduced to cyanide of methyl, $CH^3.CN$. Marsh-gas, or hydride of methyl, $CH^3.H$, is produced by the decomposition of acetates (p. 12); and cacodyl $As(CH^3)^2$, by the decomposition of acetic acid. The formation of acetone or methyl-acetyl, $CH^3.C^2H^3O$, from acetates, and the corresponding transformations of propionates, valerates, &c. (p. 26), is another example of the same kind of decomposition. Again it has been shown by Wanklyn (Chem. Soc. Q. J. xi. 103), that sodium-ethyl subjected to the action of carbonic anhydride is converted into propionate of sodium:

$$\underbrace{C^2H^5.Na}_{\text{Sodium-ethyl.}} + CO^2 = (\underbrace{C^2H^5.CO).Na.O}_{\text{Propionate of sodium.}};$$

and in like manner, acetate of sodium may be prepared from sodium-methyl. Lastly, many organic compounds, such as sugar, starch, alcohol, and acetone, which are convertible into acetic acid by oxidation, may also, under the influence of chlorine, or bromine, be converted into bodies belonging to the methyl-series, viz. chloroform, $C(HCl^2).Cl$, and bromoform, $C(HBr^2).Br$. It must be observed, however, that the representation of acetic acid as a methyl-compound applies chiefly to a state of transition, just as the acid is being produced from or converted into a body belonging to a different series, and exhibiting different chemical relations; so long as we are concerned with the transformation of one acetyl-compound into another, such as that of acetic acid into chloride or bromide of acetyl, or of the chloride into acetic anhydride, the formula $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O$ is sufficient for the representation of all the changes which take place.

The hydrogen in acetyl may be partly or wholly replaced by other elements, viz. chlorine, bromine, &c.; and hence arise the conjugate or derivative radicles, *bromacetyl*, *chloracetyl*, &c., which, like acetyl itself, are hypothetical, not having yet been isolated. The following table exhibits a general view of the compounds of acetyl and of the radicles derived from it by substitution.

Bromide of Acetyl	$C^2H^3O.Br$	
Chloride	$C^2H^3O.Cl$	
Iodide	$C^2H^3O.I$	
Hydride	$C^2H^3O.H$	Aldehyde
Hydrate	$C^2H^3O.H.O$	Acetic acid
Oxide	$(C^2H^3O)^2.O$	Acetic anhydride
Peroxide	$C^2H^3O.O$	
Sulphydrate	$C^2H^3O.H.S$	Thiacetic acid
Sulphide	$(C^2H^3O)^2.S$	Thiacetic anhydride
Nitrides	$C^2H^3O.H^2.N$	Acetamide
	$(C^2H^3O)^2.H.N$	Diacetamide
	$C^2H^3O.C^2H^5.H.N$	Ethyl-acetamide
	&c. &c.	
Hydrate of Bromacetyl	$C^2H^2BrO.H.O$	Bromacetic acid
Nitride	$C^2H^2BrO.H^2.N$	Bromacetamide
Hydrate of Dibromacetyl	$C^2HBr^2O.H.O$	Dibromacetic acid
Nitride	$C^2HBr^2O.H^2.N$	Dibromacetamide
Hydride of Tribromacetyl	$C^2Br^3O.H$	Bromal
Hydrate of Chloracetyl	$C^2H^2ClO.H.O$	Chloracetic acid
Nitride	$C^2H^2ClO.H^2.N$	Chloracetamide
Chloride of Trichloracetyl	$C^2Cl^3O.Cl$	Chloraldehyde
Hydride	$C^2Cl^3O.H$	Chloral
Hydrate	$C^2Cl^3O.H.O$	Trichloracetic acid
Nitride	$C^2Cl^3O.H^2.N.$	Trichloracetamide
Phosphide	$C^2Cl^3O.H^2.P.$	Trichloracetyphide
Hydrate of Iodacetyl	$C^2H^2IO.H.O$	Iodacetic acid
Nitride	$C^2H^2IO.H^2.N$	Iodacetamide
Hydrate of Di-iodacetyl	$C^2HI^2O.H.O$	Di-iodacetic acid
Nitride	$C^2HI^2O.H^2.N.$	Di-iodacetamide
Hydride of Tri-iodacetyl	$C^2I^3O.H.$	Iodal

Bromide of Acetyl. $C^2H^3O.Br$.—Prepared by slowly adding glacial acetic acid to pentabromide of phosphorus in a tubulated retort, distilling, and rectifying:

$$C^2H^3O.H.O + PBr^3.Br^2 = C^2H^3O.Br + HBr + PBr^3O.$$

It is a colourless liquid, boiling at 81°. When exposed to the air, it fumes strongly and immediately turns yellow. It colours the skin yellow, and is said to impart to it the odour of phosphuretted hydrogen; but this must arise from impurity. Water decomposes it into acetic and hydrobromic acids. (Ritter, Ann. Ch. Pharm. xcv. 209.)

Chloride of Acetyl. $C^2H^3O.Cl$.—Produced by the action of oxychloride of phosphorus on acetate of potassium:

$$3(C^2H^3O.K.O) + POCl^3 = 3C^2H^3OCl + PO^4K^3;$$

or in the same manner as the preceding compound, by distilling glacial acetic acid with pentachloride of phosphorus:

$$C^2H^3O.H.O + PCl^3.Cl^2. = C^2H^3O.Cl + HCl + PCl^3O.$$

Gerhardt, who discovered this compound (Ann. Ch. Phys. [3] xxxvii. 294), prepared it by adding oxychloride of phosphorus, drop by drop, to fused acetate of potassium. A brisk action then takes place, and sufficient heat is produced to cause the chloride of acetyl to distil over into the receiver, which must be well cooled. The distillate may be freed from excess of oxychloride of phosphorus by re-distillation over acetate of potassium, then distilled by itself, and the liquid which passes over at 55° collected apart. The re-distillation over acetate of potassium is, however, attended with some loss, in consequence of the formation of acetic anhydride.

$$C^2H^3O.Cl + C^2H^3O.K.O = (C^2H^3O)^2O + KCl.$$

For this reason, Ritter recommends the preparation of chloride of acetyl by the action of pentachloride of phosphorus on glacial acetic acid, the product being thereby obtained in larger quantity and more easily purified.

Chloride of acetyl is a colourless, very mobile, strongly refracting liquid, of specific gravity 1·125 at 11°, 1·1305 at 0°, and 1·1072 at 16° (Kopp). Boils at 55°. Vapour-density, 2·87 (Gerhardt): by calculation (2 vol.) = 2·718. It fumes slightly in the air, and has a pungent odour like that of acetic and hydrochloric acid. The vapour attacks the eyes and respiratory organs very strongly.

Chloride of acetyl is decomposed with explosive violence by water, yielding acetic and hydrochloric acids:

$$C^2H^3OCl + H^2O = C^2H^4O^2 + HCl.$$

Ammonia acts strongly upon it, forming acetamide:

$$C^2H^3O.Cl + H^3N = C^2H^3O.H^2.N + HCl.$$

Similarly with phenylamine, it forms phenylacetamide $C^2H^3O.C^6H^5.H.N$. Distilled with acetate of potassium, it yields acetic anhydride:

$$C^2H^3O.K.O + C^2H^3O.Cl = (C^2H^3O)^2O + KCl;$$

and with benzoate of potassium it forms benzoate of acetyl or acetate of benzoyl:

$$C^7H^5O.K.O + C^2H^3O.Cl = C^2H^3O.C^7H^5O.O + KCl;$$

and similarly with the salts of other acids. With thiacetate of lead, it forms chloride of lead, and probably also thiacetic anhydride:

$$(C^2H^3OS)^2Pb'' + 2C^2H^3OCl = 2(C^2H^3O)^2S + Pb''Cl^2.$$

When it is heated with zinc in a sealed tube, the metal is strongly attacked; and a black tarry substance is formed, from which water dissolves chloride of zinc, and separates a liquid having an ethereal odour.

Hydride of Acetyl. See ALDEHYDE.

Iodide of Acetyl. $C^2H^3O.I$.—Obtained by the action of iodide of phosphorus on acetic anhydride (Guthrie, Phil. Mag. [4] xiv. 183), or on acetate of potassium; (Cahours, Compt. rend. xliv. 1253). After being shaken up with mercury and redistilled, it forms a transparent colourless liquid, of sp. gr. 1·98 at 17°. It boils at 108° (Guthrie); between 104° and 105° (Cahours). It fumes strongly in the air, has a very pungent odour, and an intensely sour caustic taste.

Iodide of acetyl is partially decomposed by distillation. Water decomposes it with violence, forming hydriodic and acetic acids. It acts strongly upon alcohol, forming acetate of ethyl. It is decomposed by zinc and by sodium at ordinary temperatures, also by mercury in direct sunshine, iodide of mercury being formed, and little or no permanent gas being given off.

Peroxide of Acetyl. $C^2H^3O.O$. — Discovered by Brodie in 1858 (Proceedings of the Royal Society, ix. 361.) It is obtained by mixing acetic anhydride and peroxide of barium, in equivalent proportions, in anhydrous ether. The mixture must be effected very gradually, as it is attended with great evolution of heat. The products are acetate of barium and peroxide of acetyl, the latter remaining dissolved in the ether:

$$2(C^2H^3O)^2O + BaO^2 = (C^2H^3O^2)^2Ba'' + 2(C^2H^3O.O).$$

The ethereal solution, after filtration from the acetate of barium, is carefully distilled at a low temperature, and the remaining liquid is washed three or four times with water till the wash-water ceases to be acid. The residue is peroxide of acetyl.

It is a viscid liquid, extremely pungent to the taste, the smallest portion placed upon the tongue burning like cayenne pepper. It is a powerful oxidising agent, and highly explosive: a drop heated on a watch-glass explodes with a loud report, shivering the glass to atoms. Baryta-water poured upon it is instantly converted into peroxide of barium, with formation of acetate of barium.

Acetyl-urea. (See UREAS (Compound) and CARBAMIDE.)

ACETYLENE. (See ADDENDA, p. 1111.)

ACETYLOUS ACID. ALDEHYDIC ACID. *Lampic acid, Etheric acid.* An acid supposed to be produced by the slow combustion of ether or of alcohol, and under certain circumstances by the oxidation of aldehyde. When ether is repeatedly distilled, or allowed to fall in successive drops on a solid body heated to about 129°, so that its vapour may come in contact with the air at a high temperature, a disagreeable pungent odour is produced, supposed to be that of aldehydic acid. The compound possessing this odour is formed in larger quantity, when a spiral of fine platinum wire, previously heated to redness, is suspended over a basin containing ether, and the whole covered with a bell-jar. The wire then continues to glow, the ether undergoing a slow combustion without flame, and an acid liquid is formed, which runs down the sides of the bell-jar, and may be collected in a vessel placed below. This liquid is colourless, has a very sour taste, and gives off a pungent vapour which excites tears, and causes great oppression when inhaled. The same compound is obtained, according to Liebig, by heating oxide of silver with aqueous aldehyde; part of the silver is then reduced, while the other portion remains in solution in the form of acetylite of silver, and by decomposing this silver-salt with sulphuretted hydrogen, the acid may be obtained in the free state. It is, however, very liable to decompose, as also are its salts. When the silver-salt is boiled with baryta-water, silver is reduced and acetate of barium remains in solution.

$$\underbrace{4C^2H^3AgO}_{\text{Aldehydate of silver.}} + \underbrace{2BaH^2O^2}_{\text{Hydrate of barium.}} = \underbrace{(C^2H^3O)^2Ba}_{\text{Aldehydate of barium.}} + \underbrace{(C^2H^3O^2)^2Ba}_{\text{Acetate of barium.}} + 4Ag + 2H^2O.$$

Gerhardt (Traité i.) is of opinion that the so-called aldehydic or acetylous acid is merely a mixture of aldehyde and acetic acid, the aldehydate or acetylite of silver being in fact merely aldehyde in which 1 atom hydrogen is replaced by silver.

ACHILLEA MILLEFOLIUM (*Millefoil.*)—The ash of this plant has been analysed by Way and Ogston. 100 parts of the dry herb left 13·45 per cent. ashes containing in 100 parts 30·37 parts of potash, 13·40 lime, 3·01 magnesia, 0·21 sesquioxide of iron, 2·44 sulphuric anhydride, 9·92 silica, 9·36 carbonic anhydride, 7·13 phosphoric anhydride, 20·49 chloride of calcium, and 3·63 chloride of sodium.

ACHILLEIC ACID. An acid said to exist in millefoil (*Achillea Millefolium*). It crystallises in colourless prisms, soluble in 2 parts of water at 12°·5. With the alkalies it forms salts which are easily soluble in water, but sparingly in alcohol. The solutions are precipitated by neutral acetate of lead, whereas the free acid is precipitated by the basic acetate only. The potassium, sodium, and calcium salts are crystallisable: the ammonium and magnesium salts dry up to amorphous masses. The *quinine* salt is said to be obtained in fine crystals grouped in stars, when its aqueous solution is mixed with alcohol, then boiled and left to cool slowly (Zanon, Ann. Ch. Pharm. lviii. 31). Neither the acid nor its salts have been analysed. L. Gmelin, (Handbook, x. 207) suggested that this acid might be impure malic acid. According to Hlasiwetz (J. pr. Chem. lxii. 429) it is aconitic acid.

ACHILLEIN. A bitter substance of unknown composition, extracted by Zanon from millefoil. It forms a hard, yellowish brown extract, having a peculiar odour and bitter taste, easily soluble in water and in boiling alcohol, sparingly in cold alcohol and insoluble in ether; but on treating it with a few drops of any acid, it becomes easily soluble in ether; it dissolves also in ammonia. It is said to be useful as a remedy against fever.

ACHIRITE. (See DIOPTASE.)

ACHMITE. A mineral first distinguished by Ström. It has a brown-black or red-brown colour on the outside, blackish or dark greyish green on the fractured surfaces; in thin fragments it is translucent, and exhibits a yellowish-brown colour. Sp. gr. 3·43 to 3·53. Scratches glass. Melts to a black bead before the blowpipe. It crystallises in oblique four-sided prisms with truncated lateral edges and very sharp four-sided terminal faces, the edges of which correspond with the lateral edges of the oblique prism. It has four cleavages, two parallel to the sides of the oblique prism, and the other two, less obvious, parallel to the truncations of the acute lateral edges. According to the analyses of Berzelius and Rammelsberg, its composition is $NaO.SiO^3 + Fe^2O^3.2SiO^3$ ($Si = 21{\cdot}5$. $O = 8$; $Fe = 28$) or $2Na^2O.2SiO^2 + 2(Fe^2O^3.3SiO^2)$ ($Si = 28$; $O = 16$; $Fe = 56$). It occurs, though rarely, embedded in granite at Eger, and in syenite, near Porsgund in Norway.

ACHROÏTE. A name given to the colourless variety of tourmalin.

ACHTARANDITE. A name given by Breithaupt to a doubtful mineral, hitherto found only in decomposed crystals (trigonal dodecahedrons) which occur in association with vesuvian from Vilui (viluite): they are perhaps derived from helvin.

ACIBROMIDES, ACICHLORIDES, &c. (See OXYBROMIDES, OXYCHLORIDES, &c. &c.)

ACICULITE. (*Acicular Bismuth, Needle ore.*) A native sulphide of bismuth, containing also sulphides of copper and lead. The formula assigned to it by Dana is $(3CuS + Bi^2S^3) + 2(3PbS + Bi^2S^3)$, showing it to be analogous to Bournonite, with which it is isomorphous.

It occurs embedded in white quartz, and accompanying gold, at Beresof, in Siberia.

ACIDIMETRY. The determination of the quantity of real acid in a sample of hydrated acid, is a problem of frequent occurrence, both for scientific and for technical purposes. As the specific gravity of a mixture of acid and water always increases with the proportion of acid present, and as, moreover, a certain specific gravity always corresponds to a certain strength, provided no foreign substances are present, it follows that if the specific gravity corresponding to each particular percentage of real acid has once been accurately determined and tabulated, the strength of any given sample of aqueous acid may always be determined by taking its specific gravity and referring to the tables. (See SULPHURIC, NITRIC, HYDROCHLORIC ACID, &c.) This method is in fact much used, the density being generally taken with the specific gravity bottle for scientific purposes, and with the hydrometer for commercial estimations. This method, however, necessarily supposes that the acid is pure; the presence of any foreign substance, such as nitrate of sodium in nitric acid, cream of tartar and extractive or colouring matter in vinegar, &c. would altogether destroy the accuracy of the result. Moreover, in some acids, the specific gravity varies so little for considerable difference of strength, that a very slight inaccuracy of observation entails a large error in the result. In acetic acid. for example (p. 11), an increase of strength amounting to 1 per cent. produces on the average, an increase of density not exceeding 0·0034. For these reasons it is essential, especially for technological purposes, to adopt some ready and exact method of determining the strength of an acid, independently of its specific gravity.

The strength of an acid may be estimated:

a. By *Volumetric analysis*, that is by ascertaining the measured quantity of a standard alkaline solution required to saturate a given volume of the acid. (See ANALYSIS, VOLUMETRIC.)

b. By *Weight analysis*. This mode of estimation might be conducted in various ways: for instance, by converting a given quantity of the hydrated acid into a neutral salt of potassium, sodium, barium, lead, silver, &c. either by saturation or precipitation, weighing the salt thus formed, and calculating the quantity of acid from its known composition. This method is indeed constantly adopted in scientific chemistry; but is for the most part too tedious for technical purposes. A quicker method is to decompose a known weight of the acid with an excess of acid carbonate of sodium or potassium, and estimate by weight the quantity of carbonic anhydride evolved. The quantity of real acid in the sample of hydrated acid is then easily calculated; for each atom of a monobasic acid, expels 1 atom of carbonic anhydride ($CO^2 = 44$,) and each atom of a dibasic acid expels two atoms of carbonic anhydride ($2CO^2 = 88$): this will be seen from the following equations:

For hydrochloric acid:

$$CO^3NaH + ClH = ClNa + CO^2 + H^2O.$$
$$CO^2 : ClH = 44 : 36{\cdot}5$$

For acetic acid:

$$CO^3NaH + C^2H^3O^2.H = C^2H^3O^2.Na + CO^2 + H^2O$$
$$CO^2 : C^2H^3O^2.H = 44 : 60$$

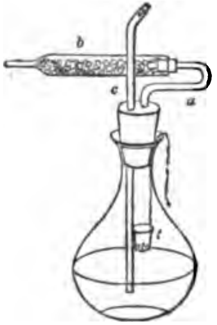
For sulphuric acid:

$$2CO^3NaH + SO^4H^2 = SO^4Na^2 + 2CO^2 + 2H^2O$$
$$2CO^2 : SO^4H^2 = 88 : 98 = 44 : 49$$

Suppose, for example, that 13·5 grm. of hydrated sulphuric acid thus treated with acid carbonate of sodium, eliminate 1·4 grains of carbonic anhydride. The quantity of real acid (SO^4H^2) in the 12·5 grm. is then $1·4 \times \frac{49}{44} = 1·47$ grm. and the quantity of real acid in 100 parts of the hydrated acid will be given by the equation: $x = 1·47 \times \frac{100}{13·5} = 10·89$.

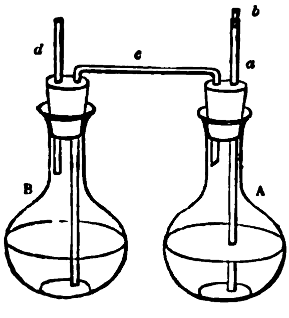
A convenient apparatus for these determinations is a small light glass flask (*fig.* 1) of about 100 cubic centimetres (3 or 4 oz.) capacity, having a lipped edge, and fitted with a cork perforated with two holes. Into one of these apertures is fitted a bent tube *a*, carrying a drying tube *b*, filled with chloride of calcium, and into the other, a narrow tube *c*, reaching nearly to the surface of the liquid, and bent at an obtuse angle above the cork. A convenient quantity of the acid whose strength is to be determined, having been weighed out in the flask, a quantity of acid carbonate of sodium or potassium more than sufficient to neutralise the acid, is placed in a small test-tube about an inch long, and having its lip slightly turned over, so that it may be suspended by a thread. This tube is then let down into the flask by the thread, but not low enough to come in contact with the acid; the thread is fixed in its place by inserting the cork into the neck of the flask, and the whole apparatus is weighed. The orifice of the bent tube *c*, is then closed with a plug of cork or wax, the cork of the flask loosened sufficiently to allow the short tube *t*, containing the alkaline carbonate to drop into the acid, and the cork immediately tightened. The carbonate is now decomposed by the acid, and carbonic anhydride escapes through the drying tube, the chloride of calcium retaining any moisture that may be carried along with it. When the effervescence ceases, the flask must be warmed to ensure the complete removal of the carbonic acid from the liquid, and after it has cooled, the plug must be removed from the bent tube *c*, and air drawn through the apparatus by applying the mouth to the extremity of the chloride of calcium tube, in order to remove all the carbonic anhydride remaining in the flask, and replace it by air. The whole is then again weighed, and the loss of weight gives the quantity of carbonic anhydride which has escaped. At the completion of the experiment, a piece of blue litmus paper must be thrown into the liquid in the flask; if it remains blue, the determination may be considered exact; but if it is reddened, there is still free acid in the flask, showing that the quantity of carbonate introduced was not sufficient to decompose it. In that case, a second small tube containing alkaline carbonate must be introduced as before, the apparatus again weighed, and the whole process repeated. The second loss of weight added to the first, gives the total quantity of carbonic anhydride evolved.

Fig. 1.



Another form of apparatus for these estimations, devised by Will and Fresenius, is shown in *fig.* 2. A and B are two small flasks, having strong necks turned over in a lip. Each of them is closed with a tight-fitting cork pierced with two holes. Through the cork of A there passes a straight tube *a*, reaching nearly to the bottom of the flask; a tube *c*, bent twice at right angles, passes through both corks, terminating just below that of A, but reaching nearly to the bottom of the flask B; a straight tube *d* also passes through the cork of B, terminating just below it. The tube *a* is closed at the extremity *b* with a plug of wax. The acid to be estimated is weighed out in the flask A; the other flask B is filled to about one-third with strong sulphuric acid; and the whole apparatus is connected in the manner shown in the figure, the proper quantity of acid carbonate of sodium being introduced into A in a short test-tube, suspended by a thread in the manner described with the former apparatus. The whole apparatus is then weighed, the cork *a* loosened, so as to allow the tube containing the carbonate to fall into the acid, and the cork immediately secured. Carbonic anhydride is now evolved, and is obliged to pass through the sulphuric acid in B, whereby it is completely dried. As soon as gas ceases to escape, the flask A is immersed in water at about 50° or 60° C. till the fresh evolution of gas thereby occasioned ceases. The wax-plug is then loosened, to

Fig. 2.



prevent the sulphuric acid in B from being forced into A, in consequence of diminished pressure in that vessel; the apparatus is removed from the hot water; and air is sucked through the tube *d* as long as any taste of carbonic acid is perceived. Lastly, the apparatus, when quite cold, is re-weighed, and the loss of weight gives the quantity of carbonic anhydride evolved.

This apparatus is much heavier and more bulky than that before described, and does not appear to possess any advantage over it. Mohr points out, as a source of inaccuracy in its use, that the large surface of the two flasks, being heated during the experiment, is not likely, on cooling, to condense exactly the same quantity of moisture as was attached to it before.

It is of the utmost importance that the acid carbonate of sodium or potassium, used in these determinations, be quite pure and free from neutral carbonate. The acid carbonates give a white precipitate with chloride of mercury, and the neutral carbonates a red-brown precipitate; but this test will not indicate the admixture of a small quantity of neutral carbonate with the acid carbonate. A more certain test of purity is to weigh out two equal portions of the acid carbonate, ignite one in a platinum crucible, and determine the quantity of carbonic anhydride given off from the other by the action of the acid in the apparatus represented in *fig.* 2 (See ALKALIMETRY). The quantity of neutral carbonate of sodium remaining after the ignition should be to that of the carbonic anhydride evolved as 106 to 44; and that of the neutral carbonate of potassium to the carbonic anhydride as 138 : 44.

If the acid carbonate is not pure enough to give a white precipitate with chloride of mercury, it should be at once rejected. Commercial acid carbonate of sodium, which will stand that test, may be further purified by triturating it to a uniform powder, covering it with an equal weight of cold distilled water, leaving it for 24 hours, then washing it two or three times on a filter with a small quantity of cold water, leaving it to drain, and drying it by exposure to the air without heating. Acid carbonate of potassium may be purified by recrystallisation. (For further details on Acidimetry, see *Dictionary of Arts, Manufactures, and Mines*, new edition, vol. i. p. 23.)

ACIDS. Salts of hydrogen. The following properties are common to the most important acids,—

1. Solubility in water.
2. A sour taste. (In those acids which possess the most strongly marked characters, this property can be perceived only after dilution with a large quantity of water.)
3. The power of reddening most organic blue and violet colouring matters (for example, litmus), and of restoring the original colour of substances which have been altered by alkalis.
4. The power of decomposing most carbonates, causing effervescence.
5. The power of destroying, more or less completely, the characteristic properties of alkalis, at the same time losing their own distinguishing characters, and forming alkaline salts.

The last is the only one of these properties which can be considered essential to acids; indeed, comparatively few acids possess them all. Moreover, there are many substances which possess, in a greater or less degree, all these properties, but which are never included among acids; of these it will be sufficient to mention *alum* (sulphate of potassium and aluminium). Alum is soluble in water; its solution has a taste which, though not purely sour, approaches much more nearly to sourness than that of many acids (benzoic acid, for example); its solution also reddens litmus, causes brisk effervescence with alkaline carbonates, and neutralises completely the alkalinity of potash or soda, forming an alkaline sulphate.

In order to get a more exact idea of what it is which essentially constitutes acidity, it may be useful to consider briefly the opinions which have successively been held upon the subject by the chemists of past times.

In ordinary language, *acid* is equivalent to *sour;* and in both Greek and Latin, the idea of "sourness" was expressed by almost the same word as that used for "vinegar," the only acid known to the ancients (thus, *Gr.* ὀξύς, sour; ὄξος, vinegar: *Lat. acidus*, sour; *acetum*, vinegar). It does not, however, appear that very great importance was at any time attached to sourness as a characteristic of acids from a chemical point of view. The number of known acids was first increased by the labours of the Arabian chemists[*]; and the solvent power which many of them exert on substances which are insoluble in water, seems first to have caused them to be regarded as a special class of substances. Thus, Geber (middle of the eighth century), who was acquainted with nitric acid and with an impure kind of sulphuric acid, speaks of these bodies under the common name of *aquæ dissolutivæ*. The idea of corrosiveness, or at least a kindred idea, which may perhaps be expressed with tolerable accuracy as that of *chemical activity*, seems to have been long connected by chemists with the idea of acidity. For example, Van Helmont (lived 1577 to 1644) attributed the active properties of quick-lime to a peculiar acid, which he supposed limestone to obtain from the fire during burning. Stahl (lived 1660 to 1734), who supposed the earths and alkalis to have the same qualitative composition (see Art. ALKALI), represented the alkalis as containing, in larger proportion than the earths, an acid principle to which they owed their greater chemical activity; and even as lately as 1764, a similar idea to that of Van Helmont was applied by Meyer to explain a large number of phenomena. This chemist endeavoured to explain the different properties of the caustic and carbonated alkalis and alkaline earths, by supposing the former to be combinations of the latter with a substance which he called *acidum pingue* (fatty acid), because, as he thought, fat-like properties could be perceived by the sense of touch in its combinations with alkalis (caustic alkalis). The idea that corrosiveness is the most important characteristic of acids, was also plainly uppermost in the mind of Lemery, when (1675) he attributed the properties of acids to a sharp-pointed form of their smallest particles.

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[*] Almost all the historical statements contained in this article, for which no reference is given, are made on the authority of Kopp, "Geschichte der Chemie," 4 vols. 8vo. Brunswick, 1843–47.

That the properties of acids are, in some important respects, opposed to those of alkalis, was perceived at a comparatively early period. This opposition of properties was in fact the basis of the medical theory of the Iatro-chemists (from the first quarter of the 16th century to the middle of the 17th century). According to them, the constituents of the human body had, some of them an acid, the rest an alkaline nature; the undue preponderance, or want of acidity or of alkalinity was the cause of disease, the condition of perfect health being a particular relation between these two opposing qualities. Otto Tachenius, a chemist of this school, gave, in 1668, as the essential character of an acid, its power of combining with alkalis to form salts; and accordingly he included silica among acids. Boyle was well acquainted with the properties which are now considered most distinctive of acids. He characterised acids by the solvent power which they exert on various substances with various degrees of energy; by their power of precipitating sulphur and other substances from solution in alkali; by their power of changing the blue colour of many plants to red, and the red of many others to bright red, and of bringing back to their original colour those which have been changed by alkali; and lastly by their forming with alkalis so-called neutral salts, at the same time losing the properties just mentioned. This enumeration of the distinctive qualities of acids differs in no important respect from that given at the beginning of this article.

Various suppositions have been made, from time to time, in order to account for the properties possessed in common by the most strongly marked acids. In order to understand these, it must be borne in mind that the distinction which most chemists are now accustomed to make between acids and salts, dates only from the time of Lavoisier, that is, from the end of the last century; and that, till his time, acids, alkalis, and the substances now by preference called salts, were all included under the common term *salts*. But since the acids then known were comparatively few, and, as was natural, were those of which the acid properties are most evident, the apparent difference between acids and other salts was much greater then than it is now.

The first theory of the constitution of acids was proposed by Becher in his "Physica Subterranea," published in 1669. He attributed the common properties of acids to their containing a common principle of acidity (*acidum primigenium*), formed by the union of primitive earth[*] and water, and supposed that the distinguishing characters of each acid were due to the particular substance which it contained mixed with the primitive acid.

The ideas of Lemery regarding acids have already been referred to.

He was followed by Stahl, who, in 1723, revived and extended Becher's theory. The following may be taken as a summary of Stahl's views:—The essential properties of all saline substances are: to affect the sense of taste, or to have sapidity; to be soluble in water; and with regard to other chief properties, such as specific gravity and fixity, to be intermediate between water and pure earth. In some salts the saline properties are very marked, in others they are less prominent, and in some they are barely perceptible. Those substances which are most saline, acids and alkalis, have a great tendency to combine with bodies which have not saline properties, and to impart such properties to them. Hence we may conclude that some substances are in themselves essentially saline, while others exhibit saline properties merely because they contain a substance essentially saline as one of their constituents.

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[*] According to Becher there were three primitive earths,—the vitrifiable, the combustible, and the mercurial,—which were the causes respectively of fusibility, of combustibility, and of volatility; thus corresponding to what the alchemists understood by salt, sulphur, and mercury.

We must regard as belonging to the former class those bodies which not only possess saline properties (taste, solubility, &c.) but which can impart these properties to other bodies by combining with them, and which, when separated from their combinations, recover their original qualities. Hence, all acids and alkalis, fixed and volatile, liquid and solid, must be considered as essentially saline. But, comparing these bodies among themselves, we find that even they possess saline properties in very various degrees. It appears, therefore, that there is only a very small number of actual primitive salts, or rather that there is only one such substance, which is a constituent of all other saline bodies, and is the cause of their saline properties. It is obvious that this substance must be sought among bodies which most distinctly and most invariably manifest saline properties, and which are, at the same time, most simple in their composition. Following this rule, we may at once exclude neutral salts, as being resolvable into more simple saline substances; again, alkalis are more subject to alteration and to loss of their saline properties than acids; they must, therefore, be excluded. Of acids, we may select mineral acids as the most energetic. Lastly, of all mineral acids, *vitriolic* (sulphuric) is the most active, has the greatest solvent powers, adheres most forcibly to the matter dissolved, is the most deliquescent, &c. &c. Accordingly, acids must be considered as the basis of all other saline bodies, and vitriolic acid as the basis of all acids. (Macquer's Dictionnaire de Chimie [1st. Edit. published anonymously, Paris, 1766] Articles "Acide" and "Sel;" Kopp, iii. 15; also Encyclopédie, ou Dictionnaire raisonné des Sciences, des Arts, et des Métiers, * * mis en ordre et publié par MM. Diderot et D'Alembert, t. xiv. [Neufchâtel, 1765] Article "Sel et Sels." The chemical part of this work was by Malouin).

Such were the ideas respecting acids and the cause of acidity, which, with unimportant variations, were held by almost all chemists until the rise of the antiphlogistic system of chemistry. (See Combustion.) But before the downfall of the older system, chemists had begun to have more exact notions than formerly of what were elementary bodies, and to feel the necessity of considering as elements all bodies which they could not decompose. Hence, although Stahl regarded sulphuric acid as a secondary principle, formed by the union of the primitive principles of earth and water, and the other acids as compounds of sulphuric acid with various substances, many of the last upholders of the phlogistic theory regarded most of the inorganic acids as simple substances. For instance, phosphoric and sulphuric acids were supposed to be elements which, when combined with phlogiston, formed phosphorus and sulphur respectively. Sulphurous acid was one of the few inorganic acids which were regarded as compounds; it was supposed to be sulphuric acid combined with less phlogiston than was needed to convert it into sulphur; or, what was the same thing, to be sulphur deprived of part of its phlogiston.

But all previous ideas about acids were gradually superseded by those of Lavoisier. Having found, experimentally, that carbonic, nitric, phosphoric, sulphurous and sulphuric acids, all contained the then newly-discovered substance — oxygen (discovered August 1st, 1774), Lavoisier concluded that oxygen was a constituent of all acids,— that it was the acidifying principle. (Lavoisier, Traité élémentaire de Chimie (1st edit. 1789), i. 69 *et passim;* Kopp, i. 308; also iii. 17.)

He first proposed this theory of acids in 1778; and, although acids were known in which no oxygen could be detected, nearly all chemists continued for about thirty years to consider the assumption, that acidity was in every case due to the presence of oxygen, as a necessary part of the antiphlogistic doctrine. Berthollet, indeed, as early as 1789, pointed out that hydrosulphuric and prussic acids contained no oxygen; but it was not till about 1810, after Davy's and Gay-Lussac and Thénard's researches on muriatic and oxy-muriatic acids (hydrochloric acid and chlorine) that chemists generally began to admit the existence of acids free from oxygen. The conclusions drawn from these experiments were confirmed by Gay-Lussac's discovery of hydriodic acid in 1814, and by his examination of prussic acid in 1815. From this time, most chemists recognised two classes of acids — those containing oxygen (oxygen-acids), and those containing no oxygen (hydrogen acids). Attempts, however, were still made to discover a constituent common to all acids, to which their common properties could be ascribed. Thus, on the one hand, Berzelius continued till 1820 to assert the necessary existence of oxygen in all acids; while, on the other hand, some chemists maintained that all acids contained hydrogen as an essential constituent.

The latter opinion was advocated by Davy. His ideas about acids appear to have been essentially the following:—No one substance ought to be regarded as the acidifying principle; the chemical properties of acids, as well as of other bodies, depend not only on the nature of their constituents, but also on their corpuscular arrangement. The so-called *hydrated* acids are the only true acids, and have a constitution similar to that of their salts. Hydrated chloric acid is a ternary compound of chlorine oxygen, and hydrogen, analogous to chlorate of potassium, which is a ternary compound of chlorine, oxygen, and potassium. The whole of the oxygen may be removed from the acid, and it will remain acid; the whole of the oxygen may be removed from the neutral salt, and it will remain neutral. We have no proof that in either of these bodies the oxygen is divided between the chlorine and the other constituent, or that either of them contains so-called anhydrous chloric acid. Similarly, there is no proof that sulphates or nitrates contain anhydrous sulphuric or nitric acid. Hydrated sulphuric and hydrated nitric acids are the true acids, and are ternary compounds, like the sulphates and nitrates. (Davy, Journal of Science and the Arts, i. 285—288; also Gilbert's Annalen, liv. 377—381; Phil. Trans. 1815, 212, 213; 218, 219; also Kopp.)

In 1816 Dulong proposed the theory, since known as the binary or hydrogen-theory of acids. He endeavoured to show that all acids were similar in constitution to hydrochloric acid; that they were all compounds of hydrogen with a radicle which was in some cases simple (as in hydrochloric and hydriodic acids), in other cases compound (as in hydrocyanic, oxalic, sulphuric, and nitric acids). His view of the constitution of these acids may be expressed by the following formulæ:—

Hydrochloric acid	$H(Cl)$
Hydriodic	$H(I)$
Hydrocyanic	$H(CN)$ or $H(Cy)$
Oxalic	$H(C^2O^4)$
Sulphuric	$H(SO^4)$
Nitric	$H(NO^6)$

Salts, according to this theory, were represented as compounds of an acid-radicle with a metal instead of with hydrogen; thus:—

Hydrochloric acid	$H(Cl)$	Nitric acid	$H(NO^6)$
Chloride of potassium	$K(Cl)$	Nitrate of potassium	$K(NO^6)$

Dulong's theory resembled Davy's in so far as it restricted the term *acid** to substances containing hydrogen (hydrated acids), and assigned an analogous constitution to acids and their salts, but differed from Davy's theory in representing the atoms of every acid as arranged in a specific manner: namely, all the atoms except hydrogen as grouped together to form a compound radicle.

These views did not attract much attention till they were applied by Liebig, in 1837, to explain the constitution of several organic acids, and of the various modifications of phosphoric acid (Ann. Ch. Pharm. xxvi. 170; Ann. Ch. Phys. lxviii. 70.), and although they are explained and discussed in a large proportion of the Manuals of Chemistry published during the fifteen or twenty years following that date, they have never been generally adopted. Until a comparatively recent date, almost all chemists continued to regard oxygen-acids as a class of bodies essentially distinct from hydrogen-acids and from metallic salts. Confining the name of oxygen-acids to the substances now known as ANHYDRIDES, they regarded oxygen-salts as bodies formed by the direct union of acids with metallic oxides, and recognised no essential distinction between actual hydrated acids (acids in the sense of Davy and of Dulong) and mere solutions of the anhydrides in water.

An important extension in the then existing views respecting acids resulted from the discovery announced by Berzelius, in 1826 (Berzel. Jahresb. vi. pp. 184 *et seq.*), that certain metallic sulphides, such as those of arsenic and antimony, were capable of uniting with the alkaline sulphides so as to form well-defined salts perfectly analogous to those formed by the combination of the corresponding metallic oxides with the alkalis. From this time, the existence of three new classes of acids (and corresponding salts) was recognised, namely, acids in which the oxygen of ordinary acids was replaced by sulphur, or by the analogous elements, selenium and tellurium.

We owe the ideas of the nature of acids, now very generally entertained, chiefly to the advance of organic chemisty, which has brought to light a very large number, not only of new acids, but of new substances of all kinds, whose chemical relations cannot be adequately expressed upon the system formerly universally adopted, of regarding all compound bodies as formed by the union of two molecules possessing opposite electrochemical characters, or of two groups, which, in their turn, have a similar binary constitution. Among the new theories which were the earliest to be thus introduced into the science, was the "Theory of Chemical Types," which represented chemical compounds as combinations of the elementary atoms held together by the attraction exerted by each atom upon all the rest, and capable of exchanging one or several atoms of one element for an equal number of atoms of another, so as to produce new substances, built up after the same plan or *type* as the original compounds, though one or more of their atoms was of a different nature. According to this view, acids and metallic salts were regarded as bodies of the same class: each acid and its corresponding salts were regarded as compounds formed upon the same type, and differing only from the fact of the acid containing hydrogen in the place of the metal contained in the salts. It will be seen that this manner of representing the mutual relation of acids and salts differed but little from that of Davy.

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* Notwithstanding the more strict use, which was made by both Davy and Dulong, of the word acid, very many chemists still use it to express bodies belonging to two very different classes: *acids* and *anhydrides*. Thus the bodies HCl, HNO^3, H^2SO^4, N^2O^5, SO^3 are all of them frequently called acids, although the first three possess marked resemblances among themselves and equally marked differences from the other two. Again, the bodies H^2SO^4 and SO^3 are often called by the same name, sulphuric acid, although they cannot be obtained in any case by the same process, and although, when caused to act upon one and the same substance, they almost always give rise to products essentially unlike. This confusion between acids and anhydrides dates from the earliest knowledge of the latter class of bodies, and was caused by the fact that the anhydrides which were first discovered immediately produce acids when they come in contact with water. Thus, Lavoisier, by burning phosphorus in oxygen, obtained phosphoric anhydride, but since the solution of this substance in water contained phosphoric acid, he supposed the anhydride to be the acid, and regarded the real phosphoric acid as a combination of phosphoric acid and water. Similarly, sulphuric acid was looked upon as containing "dry sulphuric acid" (sulphuric anhydride) and water; and all other acids, even those of which the anhydrides were unknown, as nitric and hydrochloric acids, were, in like manner, regarded as compounds of a hypothetical anhydride (often called "real acid") with water.

Another result of the progress of organic chemistry which helped to modify the older notions on these subjects, was the acquisition of more consistent ideas than had previously existed of the relative weights of different substances which are chemically comparable with each other. Thus it was discovered that an atom of water contained twice as much hydrogen as an atom of hydrochloric acid, and therefore, that the so-called monobasic acids, or acids containing the same quantity of hydrogen as hydrochloric acid, could not be compounds of water with anhydrous acids, as had been hitherto supposed. The discovery by Gerhardt in 1852 (Ann. Ch. Phys. xxxvii. 285) of the anhydrides corresponding to several monobasic acids, and the fact of their atomic weights being found to be double the atomic weights of the hypothetical anhydrides of the older theory, confirmed the same conclusion.

It is now clear that acids do not form a class apart, distinguished from other substances by something essentially different in their nature; they are, on the contrary, nothing more than a particular class of salts. The definition of acids as *salts of hydrogen*, first clearly enunciated by Gerhardt[*], and repeated at the head of this article, is an accurate statement of the relations which exist between acids and other chemical substances. This definition is, however, obviously insufficient, without a previous answer to the question — what is a salt? For this we must refer to the article SALT. In that article also the properties which acids possess in common with other salts, and which characterise them as belonging to that class, will be most suitably discussed. In the remainder of this article we shall consider the distinguishing properties of acids as such, and the mutual relations of the principal classes into which acids may be divided.

The mode in which acids most frequently react with other substances is by double decomposition, in which they exchange their hydrogen for metals, or for radicles possessing, to a certain extent, metallic functions. The following reactions are all of this kind: namely, their reactions —

1° With metals,—

$$Zn + H^2SO^4 = H^2 + ZnSO^4.$$

2° With metallic oxides, sulphides, and salts generally,—

$$\begin{array}{lllll}
KHO & + HCl & = H^2O & + KCl \\
KHS & + HCl & = H^2S & + KCl \\
PbO & + 2HCl & = H^2O & + PbCl^2 \\
FeS & + H^2SO^4 & = H^2S & + FeSO^4 \\
2NaCl & + H^2SO^4 & = 2HCl & + Na^2SO^4 \\
KNO^3 & + H^2SO^4 & = HNO^3 & + KHSO^4
\end{array}$$

3° With the hydrates of alcohol-radicles,—

$$\underbrace{C^2H^5.H.O}_{\text{Hydrate of ethyl.}} + HCl = H^2O + \underbrace{C^2H^5Cl.}_{\text{Chloride of ethyl.}}$$

4° With various metallic compounds,—

$$\underbrace{(C^2H^5)^2Zn}_{\text{Zinc-ethyl.}} + 2HCl = 2\underbrace{(C^2H^5.H)}_{\text{Hydride of ethyl.}} + ZnCl^2.$$

$$\underbrace{KH^2N}_{\text{Potassamine.}} + HCl = H^3N + KCl:$$

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[*] Précis de Chimie organique (Paris, 1844), i. 70; Introduction à l'Étude de la Chimie par le Système unitaire (Paris, 1848), 103. On the similar characters of acids, or hydrogen-salts, and of metallic salts in general, and on the important differences between them and the anhydrides, comp. Laurent, Méthode de Chimie, pp. 48-56, or Cavendish Society's translation, pp. 39 to 45.

With some substances acids unite directly: namely—

1° With ammonia and its analogues,—

$$\begin{aligned} \mathrm{NH^3} + \mathrm{HCl} &= \mathrm{NH^4Cl} \\ \mathrm{PH^3} + \mathrm{HI} &= \mathrm{PH^4I} \\ \underbrace{\mathrm{2NC^6H^7}}_{\text{Aniline.}} + \mathrm{H^2SO^4} &= \underbrace{\mathrm{(NC^6H^7)^2.H^2SO^4}}_{\text{Sulphate of aniline.}} \end{aligned}$$

2° With some hydrocarbons,—

$$\underbrace{\mathrm{C^2H^4}}_{\text{Ethylene.}} + \mathrm{H^2SO^4} = \underbrace{\mathrm{C^2H^6SO^4}}_{\substack{\text{Sulphovinic}\\ \text{acid.}}}$$

$$\underbrace{\mathrm{C^3H^6}}_{\text{Propylene.}} + \mathrm{HCl} = \underbrace{\mathrm{C^3H^7Cl}}_{\substack{\text{Chloride of}\\ \text{trityl.}}}$$

Reactions such as the above can be produced by all well characterised acids. The majority of acids can also produce other reactions of various kinds, some of which are characteristic of individual acids, while others are common to a considerable number, and therefore serve for their division into classes. The rational formulæ by which the various acids are commonly represented, indicate the nature of their leading reactions, and hence the class to which they belong.

Oxygen-acids form by far the most numerous and important class of acids. We may take acetic acid as a special example, and show how the double decompositions which it is capable of undergoing, in common with the other acids of this class, lead to the choice of the rational formulæ by which oxygen-acids in general are usually represented.

1. When acetic acid is converted into an acetate by acting upon it with an oxide, metal, or any other substance, it loses hydrogen. This may be represented by writing one atom of hydrogen in its formula apart from the rest: $\mathrm{C^2H^4O^2 = C^2H^3O^2,H}$.

2. By perchloride of phosphorus acetic acid is converted into chloride of acetyl; and loses one atom of oxygen and one atom of hydrogen. To express this, we must write the formula of acetic acid thus; $\mathrm{C^2H^3O.HO}$.

3. By the action of pentasulphide of phosphorus, acetic acid loses half its oxygen, and becomes thiacetic acid, $\mathrm{5(C^2H^4O^2) + P^2S^5 = 5(C^2H^4OS) + P^2O^5}$.

The rational formula derivable from this reaction is $\mathrm{C^2H^4O.O}$.

Combining these three expressions, we come to divide the formula of acetic acid into three parts H, $\mathrm{C^2H^3O}$ and O, and to write it $\genfrac{}{}{0pt}{}{\mathrm{C^2H^3O}}{\mathrm{H}}\mathrm{O}$, or $\mathrm{H.C^2H^3O.O}$, or in some similar way. This formula indicates beforehand all the most frequent double decompositions of which acetic acid is capable; viz. the separation of one atom of hydrogen, the other atoms remaining together (formation of acetates); the separation of one atom of hydrogen and one atom of oxygen, leaving the group $\mathrm{C^2H^3O}$ (formation of chloride of acetyl, of acetamide &c.); the separation of one atom of oxygen, leaving the remaining atoms combined (formation of thiacetic acid, &c.)

The large number of acids which resemble acetic acid as to their leading double decompositions, receive similar rational formulæ; that is to say, rational formulæ consisting of three parts: namely (1) one or more atoms of hydrogen, (2) one or more atoms of oxygen or sulphur, (3) a radicle, nearly always compound and containing oxygen, sulphur or a similar element. Thus, writing the rational formula of acetic acid $\genfrac{}{}{0pt}{}{\mathrm{C^2H^3O}}{\mathrm{H}}\mathrm{O}$, we write that of benzoic acid $\genfrac{}{}{0pt}{}{\mathrm{C^7H^5O}}{\mathrm{H}}\mathrm{O}$, of pyruvic acid $\genfrac{}{}{0pt}{}{\mathrm{C^3H^3O^2}}{\mathrm{H}}\mathrm{O}$, of oxalic acid $\genfrac{}{}{0pt}{}{\mathrm{C^2O^2}}{\mathrm{H^2}}\mathrm{O^2}$, of phosphoric acid $\genfrac{}{}{0pt}{}{\mathrm{PO}}{\mathrm{H^3}}\mathrm{O^3}$, of thiacetic acid $\genfrac{}{}{0pt}{}{\mathrm{C^2H^3O}}{\mathrm{H}}\mathrm{S}$, of sulphocarbonic acid $\genfrac{}{}{0pt}{}{\mathrm{CS}}{\mathrm{H^2}}\mathrm{S^2}$, of sulphocyanic acid $\genfrac{}{}{0pt}{}{\mathrm{CN}}{\mathrm{H}}\mathrm{S}$, of hypochlorous acid $\genfrac{}{}{0pt}{}{\mathrm{Cl}}{\mathrm{H}}\mathrm{O}$.

If in any of these formulæ we replace the radicle by its equivalent quantity of hydrogen (see EQUIVALENTS) and the sulphur (where it occurs) by its equivalent of oxygen, we obtain the formula of one, two, or three, atoms of water $\genfrac{}{}{0pt}{}{\mathrm{H}}{\mathrm{H}}\mathrm{O}$, $\genfrac{}{}{0pt}{}{\mathrm{H^2}}{\mathrm{H^2}}\mathrm{O^2}$, or $\genfrac{}{}{0pt}{}{\mathrm{H^3}}{\mathrm{H^3}}\mathrm{O^3}$. Moreover, the decompositions of which water is susceptible are essentially quite similar to those of acetic acid. Thus, when converted into a hydrate by the action of a metal or of an oxide, water loses one atom of hydrogen—$\mathrm{K + H^2O = H + HKO}$, or $\mathrm{2Ca''O + 2H^2O = Ca''H^2O^2 + H^2Ca''O^2}$; oxychloride of phosphorus converts water into hydrochloric acid, removing from it one atom of hydrogen and one atom of oxygen.

$3H^2O + POCl^3 = 3HCl + PO^4H^3$; lastly, pentasulphide of phosphorus converts it into hydrosulphuric acid, removing from it one atom of oxygen:—$5H^2O + P^2S^5 = 5H^2S + P^2O^5$. It is in this sense that water is taken as the *type*, or standard of comparison for acetic acid and all other acids which undergo similar double decompositions.

Another class of acids are, in the same way, referred to the type hydrochloric acid, HCl. These acids are susceptible of only one kind of double decomposition: their atoms are separable into only two groups, hydrogen and a radicle. Hydrobromic acid HBr, hydriodic acid HI, hydrocyanic acid HCN, are of this class.

There is still a third class of acids which may be referred to the type ammonia, NH^3. Succinimide, $C^4H^5NO^2$, cyanic acid (carbimide), CONH, and sulphocyanic acid (sulphocarbimide), CSNH, are acids of this kind. Under the influence of metallic oxides, and hydrates they part with one atom of hydrogen, and take up in exchange an atom of metal:

$$\underbrace{2(C^4H^5NO^2)}_{\text{Succinimide.}} + Ag^2O = \underbrace{2(C^4H^4AgNO^2)}_{\text{Argento-succinimide.}} + H^2O.$$

$$\underbrace{CHNO}_{\text{Cyanic acid.}} + HKO = \underbrace{CKNO}_{\text{Cyanate of potassium.}} + H^2O.$$

When boiled with dilute acids, they break up into two groups, a carbonised radicle on the one hand (which combines with oxygen or with oxygen and hydrogen derived from the water of the dilute acid), and the group HN (which combines with two atoms of hydrogen) on the other hand.

$$\underbrace{CHNO}_{\text{Cyanic acid.}} + H^2O = \underbrace{CO.O}_{\text{Carbonic anhydride.}} + \underbrace{HN.H^2}_{\text{Ammonia}}.$$

$$\underbrace{C^4H^5NO^2}_{\text{Succinimide.}} + 2H^2O = \underbrace{C^4H^4O^2.H^2O^2}_{\text{Succinic acid.}} + HN.H^2$$

These reactions show that the rational formulæ of these acids must consist of three parts; an atom of nitrogen, an atom of hydrogen, and a radicle composed of the remaining atoms. Thus the formula of succinimide must be $N.H.C^4H^4O^2$ or $N\left\{\begin{matrix}C^4H^4O^2,\\H\end{matrix}\right.$ that of cyanic acid N.H.CO, or $N\left\{\begin{matrix}CO\\H\end{matrix}\right.$. The substance called by Gerhardt nitride of benzoyl, sulphophenyl and hydrogen ($C^{13}H^{11}SO^3N$) is another acid deriving from the type ammonia. Its decompositions have not yet been much studied, but its behaviour with metallic oxides and its formation from ammonia by the successive action of the chlorides of sulphophenyl and of benzoyl ($C^6H^5SO^2Cl$ and C^7H^5OCl) require that its rational formula should be composed of the four parts N, H, $C^6H^5SO^2$ and C^7H^5O. Since the constituent atoms of this acid are separable into four groups, it is evidently susceptible of undergoing even more numerous decompositions than either the acids deriving from the type H^2O, or those previously mentioned as deriving from the type NH^3, whose atoms are separable into only three groups.

In regard to their *chemical constitution*, we may thus divide acids into three principal classes, which have the same mutual relations of formation and decomposition as hydrochloric acid*, water, and ammonia, and which may therefore be regarded as deriving from these bodies as types.

But, in the same sense as some of the acids which we have been considering, are formed from two, or from three atoms of the same type (from H^2Cl^2, H^4O^2, H^6O^3, &c.), there are certain others which are formed from two or more atoms of two (or perhaps three) different types; for example, sulphuric acid SO^4H^2, derives from the type $\left.\begin{matrix}H^2\\H^2\end{matrix}\right\}O^2$, thus $\left.\begin{matrix}(SO^2)''\\H^2\end{matrix}\right\}O^2$, while sulphamic acid, SO^3H^3N, and chlorhydrosulphuric acid, SO^3HCl, derive respectively from the double types $\left.\begin{matrix}H^3N\\H^2O\end{matrix}\right\}$ and $\left.\begin{matrix}HCl\\H^2O\end{matrix}\right\}$; thus $\left.\begin{matrix}(SO^2)''\ N\\H^3O\end{matrix}\right\}$ = sulphamic acid; $\left.\begin{matrix}(SO^2)'' & Cl\\H & O\end{matrix}\right\}$ = chlorhydrosulphuric acid. Acids of this kind may be called, for the sake of distinction, *intermediate* acids. The so-called *amic acids* (see AMIC ACIDS) afford the most numerous and best known illustrations of this class. Like sulphamic acid, they derive from the type $\left.\begin{matrix}H^2N\\H^2O\end{matrix}\right\}$. They can give rise to two kinds of double decomposition; that is, they can decompose either as hydrates (derivatives of water), or as amides (derivatives of ammonia), according to the nature of the body with which they react. In like manner, chlorhydrosulphuric acid and analogous substances can decompose either as hydrates or as chlorides (derivatives of hydrochloric acid).

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* Since the reactions of the acids of the first class are also possessed by those of the second and third classes, it is plain that, if we have regard to these reactions only, all acids may be referred to the type *hydrochloric acid*. To this extent, but no further, the hydrogen-theory represents correctly the constitution of all acids.

Another way in which acids may be classified has reference to their *basicity*: they may be divided into *monobasic*, *dibasic*, and *tribasic** acids. **Graham** was the first to call attention to the existence of polybasic acids in his paper on arsenic and phosphoric acids (Phil. Trans. 1833, 253; Phil. Mag. iii. 451, 469). The distinctions which he established between monobasic and polybasic acids, had reference merely to the composition of their salts. In 1837 **Liebig** (Ann. Ch. Pharm. xxvi. 138; Ann. Ch. Phys. lxviii. 35) showed that tartaric, citric, meconic, and some other organic acids were polybasic, but he pointed out no new general characters of polybasic acids, nor any new way of distinguishing them from monobasic acids. **Gerhardt** (Précis de Chimie Organique (1844), i. 71—84) was the first to connect the basicity of acids with other facts than the composition of their metallic salts, and he and **Laurent** (Ann. Ch. Phys. [3] xviii. 266; Méthode de Chimie, 62—76, or Cavendish Society's Translation pp. 50—62) first placed the question on its present footing.

Mono-, di-, and tri-basic acids may be defined, in a few words, as containing respectively, *one*, *two*, and *three* atoms of hydrogen replaceable by other metals, or by compound groups of analogous function. This definition, taken by itself, is, however, obviously insufficient to decide the basicity of any particular acid, since, by properly multiplying or dividing its formula, we can represent it as possessing whatever basicity we please. Hence, before we can decide what the basicity of an acid is, we must know its atomic weight, and conversely, in order to fix the atomic weight of an acid we require to know its basicity: in other words, the determination of its basicity and the determination of its atomic weight are the same thing.

To decide either of these points, we must take into consideration the general behaviour of the acid with other bodies, and the nature of its derivatives. The following are the most important general differences shown by acids of different degrees of basicity:—

a. Each *monobasic* acid can form *but one* ether. This is neutral in its properties. Two volumes of its vapour contain only *one* volume of ethyl, or alcohol-residue. Monobasic acids do *not* form acid ethers.	*a.* Each *dibasic* acid can form *two* ethers; one of them neutral, the other acid. (Thus, sulphuric acid forms sulphate of ethyl and ethyl-sulphuric acid.) Two volumes of the vapour of the neutral ether contain *two* volumes of ethyl or alcohol-residue.	*a.* Each *tribasic* acid can form *three* ethers; one of them neutral, the other two acid. (*e.g.* phosphoric acid forms phosphate of ethyl and monethyl- and diethyl-phosphoric acids.) Two volumes of the vapour of the neutral ether contain *three* volumes of alcohol-residue.
b. *Monobasic* acids cannot form stable, well-defined acid salts, or salts with two or more metallic bases.	*b.* *Dibasic* acids can form, with each metallic base, a neutral salt and an acid salt, which last is exactly intermediate in composition betweeen the neutral salt and the free acid. They can also form well-defined double salts containing two metallic bases, as well as hybrid salts containing two or more metallic bases in indefinite proportions.	*b.* *Tribasic* acids can form *three* salts with the same metallic base, two of them acid, and one neutral. They can also form double, triple, and hybrid salts.
c. *Monobasic* acids cannot form double or multiple ethers, that is, ethers containing two or more kinds of alcohol-residue.	*c.* *Dibasic* acids can form double ethers, that is, ethers containing two kinds of alcohol-residue. (Example, double oxalate of ethyl and methyl.)	*c.*

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* It is probable that tetrabasic acids also exist, but none have yet been much investigated; pyrophosphoric and silicic acids seem to be such.

The above distinctions apply to acids of all kinds, from whatever type they derive. The following apply only to acids which derive from the type *water* (oxacids).

d. Each *monobasic* oxacid can form a chloride, in two volumes of the vapour of which is contained only *one* volume of chlorine. Each such chloride can take up an atom of oxygen and an atom of hydrogen in exchange for an atom of chlorine to re-form the normal acid,—but there is no compound intermediate in composition between the chloride and the normal acid.	*d.* Each *dibasic* oxacid can form a chloride, in two volumes of the vapour of which are contained *two* volumes of chlorine. Dibasic oxacids can also form chlorides which contain, in two volumes of vapour, only *one* volume of chlorine, and are exactly intermediate in composition between the chlorides last-mentioned and the normal acids; that is, they can take up an atom of chlorine in exchange for an atom of oxygen and an atom of hydrogen, to form chlorides containing two volumes of chlorine in two volumes of vapour; or they can take up an atom of oxygen and an atom of hydrogen in exchange for an atom of chlorine, to re-form the normal acid. Thus, sulphuric acid, SO^4H^2, forms chloride of sulphuryl or chlorosulphuric aldehyde SO^2Cl^2, and the intermediate compound chlorhydrosulphuric acid, SO^3HCl.	*d.* Each *tribasic* oxacid can form a chloride in two volumes of the vapour of which are contained *three* volumes of chlorine.
e. *Monobasic* oxacids, by reacting with ammonia, or its derivatives, form neutral amides, in two volumes of the vapour of which is contained only *one* volume of nitrogen. There are no compounds intermediate between these amides and the corresponding acids.	*e.* *Dibasic* oxacids, by reacting with ammonia, or its derivatives, form neutral amides, in two volumes of the vapour of which are contained *two* volumes of nitrogen. Intermediate in composition between these amides and the corresponding acids are compounds, generally acid (amic acids), in two volumes of the vapour of which is contained but *one* volume of nitrogen. For, example, oxalic acid, $C^2O^4H^2$, forms neutral oxamide, $C^2O^2H^4N^2$, and the intermediate compound oxamic acid $C^2O^3H^3N$.	*e.* *Tribasic* oxacids, by reacting with ammonia, or its derivatives, form neutral amides, in two volumes of the vapour of which are contained *three* volumes of nitrogen. Intermediate in composition between each of these amides and the corresponding acid, there may exist two acid compounds, one monobasic and containing in two volumes of vapour *two* volumes of nitrogen: the other dibasic and containing in two volumes of vapour only *one* volume of nitrogen. For example, citric acid, $C^6H^8O^7$, forms with phenylamine (aniline) neutral citrophenylamide, $C^6H^8O^4Ph^3N^3$, ($Ph = C^6H^5 =$ phenyl), and the intermediate monobasic citrodiphenylamic acid, $C^6H^8O^5Ph^2N^2$; the dibasic citromonophenylamic acid, $C^6H^8O^6PhN$, has not yet been discovered.
f. *Monobasic* oxacids do not form acid compounds (so-called conjugate acids) by reacting with hydro-	*f.* *Dibasic* oxacids form acid compounds (conjugate acids) by reacting with hydrocarbons or other neu-	*f.* *Tribasic* oxacids form acid compounds by reacting with hydrocarbons or other neutral substances. For

carbons, or other neutral substances.	tral substances. For example, sulphuric acid reacts with benzene to form sulphobenzidic (phenylsulphurous) acid, and with glycerin to form sulphoglyceric acid.	example, phosphoric acid reacts with glycerin to form phosphoglyceric acid.

(Compare Odling, Chem. Soc. Qu. J. xi. 127.)

In addition to these, other properties of acids might be mentioned, which are connected more or less intimately with their basicity; but, notwithstanding the number of comparatively very well-defined characters which they severally possess, it is impossible to establish any absolute distinction between monobasic and dibasic, or between dibasic and tribasic acids. There are many acids, which, in relation to a particular set of reactions, have the properties of monobasic acids, but, in relation to another set of reactions, behave like dibasic acids; others, again, appear from one point of view to be dibasic, while from another point of view they seem to be tribasic. This will appear more distinctly by considering what degree of generality belongs to each of the differences we have pointed out between acids of different basicities.

a. Number of ethers. Perhaps the only exception to this law is afforded by phosphorous acid, which forms three ethers, one of them containing, in two volumes of vapour, three volumes of alcohol-residue, although, as regards its metallic salts, it is only dibasic.

b. Number of metallic salts. Acetic and formic acids, which possess in a special degree most of the characters of monobasic acids, form, each of them, two potassium- and two sodium-salts.

c. Multiple ethers. No exception to this law is known so far as regards mono- and di-basic acids. Tribasic acids ought by analogy to form ethers containing two or three kinds of alcohol residue; none such have yet been obtained, but there is no reason to suppose that they might not easily be formed.

d. Number of chlorides. Some acids, which according to *a*, *b*, and *c* would be classed as monobasic, form chlorides containing two volumes of chlorine, as well as intermediate chloracids. For instance, Wurtz's *chlorure d'acétyle chloré*, $C^2H^2Cl^2O$ (Ann. Ch. Phys. [3] xlix. 60) reacts with one atom of water to form chloracetic acid, $C^2H^3ClO^2$; and this, with a second atom of water, forms glycollic acid, $C^2H^4O^3$. These three bodies are therefore related in the same way as chloride of sulphuryl, chlorhydrosulphuric acid, and sulphuric acid. Again, lactic acid, $C^3H^6O^3$, a homologue of glycollic acid, is decomposed by pentachloride of phosphorus, giving chloride of lactyl, $C^3H^4Cl^2O$, which reacts with alcohol to form chloropropionate (chlorhydrolactate) of ethyl, $C^5H^9ClO^2$, (Wurtz, Ann. Ch. Pharm. cvii. 192); that is to say, the ether of an acid intermediate between chloride of lactyl and lactic acid. The intermediate acid itself is produced $C^3H^5ClO^2$, by the action of chloride of lactyl on water. (Ulrich, Chem. Soc. Qu. J. xii. 23; Ann. Ch. Pharm. cix. 268.) So far then as their chlorides are concerned, glycollic and lactic acids resemble dibasic and not monobasic acids. (See also observations on *e.*)

In the case of tribasic acids, no intermediate chloracids are known, such as would correspond to chlorhydrosulphuric acid and other derivatives of dibasic acids. It is probable that each tribasic acid can form two such compounds, that phosphoric acid (PH^3O^4), for example, can form chlorhydrophosphoric acid (PH^2ClO^3,) dibasic?) and dichlorhydrophosphoric acid * ($PHCl^2O^2$, monobasic?)

e. Number and nature of amides. Some monobasic acids form amides containing, in two volumes of vapour, two volumes of nitrogen. For instance, acetic acid forms *acediamine*, $C^2H^6N^2$, between which and acetic acid $C^2H^4O^2$, acetamide C^2H^5NO is exactly intermediate, (just as oxamic acid, $C^2H^3NO^3$, is intermediate between oxamide, $C^2H^4N^2O^2$, and oxalic acid, $C^2H^2O^4$); acetamide, however, is neutral, not acid, in its properties.

Certain other acids, generally considered monobasic, form amides containing one atom of nitrogen, which possess some of the properties of acids. Thus glycollic acid, $C^2H^4O^3$, forms glycocoll, $C^2H^5NO^2$, a substance capable of acting as an acid, and possessing the same relation of composition to glycollic acid, that oxamic acid does to oxalic acid, or acetamide to acetic acid. The so-called benzamic, toluamic, cuminamic. &c. acids, are substances of a similar constitution: they are to oxybenzoic, oxycuminic, &c. acids what glycocoll is to glycollic acid. In short, glycollic and similar acids, though in the strict sense *monobasic* are *diatomic*; that is, they form but one salt with each metallic base—are monobasic as regards their metallic salts,—but resemble dibasic acids so far as regards their other derivatives (chlorides and amides).

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* Chlorhydrosulphuric acid is formed when sulphuric anhydride is brought in contact with dry hydrochloric acid ($SO^3+HCl = SHClO^3$). Similarly, a liquid, which probably contains one or both of the compounds mentioned in the text, is formed when phosphoric anhydride is exposed to dry hydrochloric acid ($P^2O^5+3HCl = PH^2ClO^3+PHCl^2O^2$—?)

f. Formation of complex acids. The difference in respect of acidity between compounds formed by the reaction of monobasic and of polybasic acids on neutral substances, is a particular case of a general rule which was first announced by **Gerhardt** (Précis de Chim. Organ. i. (1844) 102; Compt. rend. Trav. Chim. 1845, 161) in the following form; $B = b' + b - 1$, where B denotes the basicity of the body resulting from the the reaction, b and b' the basicities of the reacting substances (the basicities of alkaline or neutral substances, and of mono-, di-, and tribasic acids being estimated respectively as 0, 1, 2, and 3). **Strecker** (Ann. Ch. Pharm. lxviii. 47) showed that the rule admitted of a somewhat more extended application in the form $B = b + b' - aq$, where aq denotes the number of atoms of water which separate in the reaction. **Piria** (Ann. Ch. Pharm. xcvi. 381), observing that, when more than two substances reacted upon each other, the number of atoms of water formed was usually one less than the number of reacting substances, expressed the rule of basicity in the following form, $B = b + b' + b'' + \ldots\ldots - (n-1)$, ($n$ being the number of reacting substances). In all these expressions, one substance only is regarded as the essential product of the reaction, but, if we take into consideration the basicity of all the products (water, hydrochloric acid, &c. as well as more complex substances) and regard water as a monobasic * acid, we arrive at the following expression—*The sum of the basicities of the products of a reaction is equal to the sum of the basicities of the reacting bodies.*

Examples:—

$$HCl + KHO = KCl + H^2O$$
Basicities $1 + 0 = 0 + 1$

$$H^2SO^4 + KHO = KHSO^4 + H^2O$$
Basicities $2 + 0 = 1 + 1$

$$H^2SO^4 + KHO + KHO = K^2SO^4 + H^2O + H^2O$$
Basicities $2 + 0 + 0 = 0 + 1 + 1$

$$\overbrace{C^2H^4O^2}^{\text{Acetic acid.}} + \overbrace{C^2H^6O}^{\text{Alcohol.}} = \overbrace{C^4H^8O^2}^{\text{Acetate of ethyl.}} + H^2O$$
Basicities $1 + 0 = 0 + 1$

$$C^2H^4O^2 + NH^3 = \overbrace{C^2H^5NO}^{\text{Acetamide.}} + H^2O$$
Basicities $1 + 0 = 0 + 1$

$$C^2H^4O^2 + HCl + HBr + \overbrace{C^3H^8O^3}^{\text{Glycerin.}} = \overbrace{C^5H^8O^2ClBr}^{\text{Acetochlorhydrobromhydrin.}} + H^2O + H^2O + H^2O$$
Basicities $1 + 1 + 1 + 0 = 0 + 1 + 1 + 1$

$$\overbrace{PON^3H^6}^{\text{Phosphamide.}} + H^2O + H^2O + H^2O = H^3PO^4 + NH^3 + NH^3 + NH^3$$
Basicities $0 + 1 + 1 + 1 = 3 + 0 + 0 + 0$

The application of the rule of basicity to substances which, like glycollic acid, are monatomic in some relations but diatomic in others, or, like phenylic alcohol (carbolic acid), are intermediate between neutral bodies and acids, often leads, as might be expected, to contradictory results. It must be looked upon, not as a law universally true, but as a rule applicable to the majority of cases, and always dependent on our definitions of acidity and basicity. (Comp. **Kekulé**, Ann. Ch. Pharm. cvi. 130.)

It has been pointed out by **Beketoff** (Bullet. de l'Académie de St. Pétersbourg, xii. 369) that this law, in any of the forms yet given to it, gives contradictory results when applied to the three following reactions, which nevertheless are strictly comparable with each other.

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* If water be also considered as a *monacid base*, the *acidity* of bases (or the number of atoms of acid with which they react,—a property correlative with *basicity*,) is usually conformable to the following rule:—*The sum of the acidities of the products of a reaction is equal to the sum of the acidities of the reagents.* The representation of water as a monobasic acid and as a monacid base expresses the fact that it easily takes up 1 atom of an electro-positive, or of an electro-negative radicle in exchange for an atom of hydrogen, or, an electro-positive *and* an electro-negative radicle in exchange for the two atoms of hydrogen. The representation of water as a dibasic acid (or as a diacid base) expresses the possibility of replacing both atoms of hydrogen by the same radicle (formation of anhydrides). This replacement though not unfrequent, certainly takes place less readily than the replacement of 1 atom of hydrogen only, or than the replacement of the two by radicles of different electro-chemical qualities. Either view, however, is evidently entirely relative.

$$1.\ \overbrace{C^7H^6O^2}^{\text{Benzoic acid.}} + \overbrace{C^2H^6O}^{\text{Alcohol.}} = \overbrace{C^9H^{10}O^2}^{\text{Benzoate of ethyl.}} + H^2O$$

Basicities 1 + 0 = 0 + 1

$$2.\ \overbrace{C^7H^6O^2}^{\text{Benzoic acid.}} + \overbrace{C^2H^4O^2}^{\text{Acetic acid.}} = \overbrace{C^9H^8O^3}^{\text{Aceto-benzoic anhydride.}} + H^2O$$

Basicities 1 + 1 0 + 1

$$3.\ \overbrace{C^2H^6O}^{\text{Alcohol}} + \overbrace{CH^4O}^{\text{Methylic alcohol.}} = \overbrace{C^3H^8O}^{\text{Methyl-ethyl ether.}} + H^2O$$

Basicities 0 + 0 0 + 1

According to the conventions which have been made above, the sum of the basicities of the products of the first reaction is equal to the sum of the basicities of the reagents, but in the second reaction it is less, and in the third it is greater. The obviously artificial character of the law of basicity, which is sufficiently shown by these instances, induced Beketoff to propose to compare the whole quantity of replaceable hydrogen in the reagents with that in the products, instead of merely comparing their basicities, or the number of atoms of hydrogen which are easily replaceable by basylous radicles. If the so-called typical formulæ (see FORMULÆ, RATIONAL) are employed in writing the above reactions, it at once becomes evident that in each case the whole quantity of replaceable hydrogen is two atoms, both in the products and in the reagents; and in all regular double decompositions, the whole number of atoms of replaceable hydrogen remains similarly unaltered (For an account of all that is important in Beketoff's paper, and for an extended criticism of the law of basicity, see Kekulé, Lehrbuch d. organisch. Chemie, pp. 210—219.)

A general classification of acids according to their composition cannot yet be given. There are but few elements which are known to form more than two or three distinct acids; and, although many remarkable relations can be pointed out among the acids formed by different elements, these relations are more important as indications of analogies among the elements, than as serving for the classification of the acids themselves.* There is, however, one element — carbon — which, in combination with hydrogen and oxygen, forms a very large number of acids, the best known of which, generally exhibit, when compared together, certain gradations of chemical composition and properties, in accordance with which they can be arranged in a number of *homologous series*. (See HOMOLOGY.) The most important of these series are the following: —

a. Monobasic acids represented by the general formula $C^nH^{2n}O^2$.

Formic	acid	CH^2O^2,	Caproic	acid	$C^6H^{12}O^2$,
Acetic	,,	$C^2H^4O^2$,	Œnanthylic	,,	$C^7H^{14}O^2$,
Propionic	,,	$C^3H^6O^2$,	Caprylic	,,	$C^8H^{16}O^2$,
Butyric	,,	$C^4H^8O^2$,	Pelargonic	,,	$C^9H^{18}O^2$,
Valeric	,,	$C^5H^{10}O^2$,	Rutic or capric	,,	$C^{10}H^{20}O^2$,

&c.

The acids of this series are found in various vegetable and animal products; several of them occur in combination with glycerin as the chief constituents of most natural solid and liquid fats. The first four have been found in mineral waters (Scheerer, Ann. Ch. Pharm. xcix. 257). They are produced artificially by a great variety of processes, the most important of which are the following:

1°. The oxidation of the alcohols $C^nH^{2n+2}O$

$$\underbrace{C^2H^6O}_{\text{Ethyl-alcohol.}} + O^2 = \underbrace{C^2H^4O^2}_{\text{Acetic acid.}} + H^2O.$$

2°. The decomposition of the so-called nitriles, or cyanides of alcohol-radicles, of the formula $C^nH^{2n-1}N$, by alkaline hydrates.

$$\underbrace{C^3H^5N}_{\text{Acetonitrile or cyanide of ethyl.}} + 2H^2O = \underbrace{C^3H^6O^2}_{\text{Propionic acid.}} + NH^3.$$

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* For an able exposition of nearly all that can yet be said on this point, see Odling, Phil. Mag. xviii. 368; also a lecture on "Acids and Salts," delivered by the same at the Royal Institution, 30th March, 1860, Chemical News, i. 220.

3°. The combination of the potassium- and sodium- compounds of the alcohol-radicles C^nH^{2n+1} with carbonic anydride.

$$\underbrace{C^2H^5Na}_{\text{Sodium-ethyl.}} + CO^2 = \underbrace{C^3H^5NaO^2}_{\text{Propionate of sodium.}}.$$

4°. The oxidation, destructive distillation, fermentation, or putrefactive decomposition of complex organic compounds.

When a fixed-alkaline, or alkaline-earthy salt of one of these acids is subjected to dry distillation, a carbonate and an acetone are generally produced. These products are formed by the decomposition of two atoms of the salt.

The dry distillation of a mixture of the fixed-alkaline, or alkaline-earthy, salts of *two* acids of this series gives rise, in like manner, to a carbonate and to an acetone intermediate in composition between the two acetones corresponding to the acids employed.

When one of the salts is a formate, a similar reaction takes place, but an aldehyde is then produced instead of an acetone.

In some cases the dry distillation of salts of these acids produces (besides acetones) aldehydes, or isomeric compounds (butyral, valeral) and hydrocarbons. (See ALDEHYDES, ACETONES.)

When distilled with excess of alkaline hydrate, they give hydrocarbons of the formula C^nH^{2n+2} (hydrides of alcohol-radicles) and alkaline carbonate.

$$\underbrace{C^2H^3KO^2}_{\text{Acet. potassium.}} + HKO = CK^2O^3 + \underbrace{CH^4}_{\text{Hydride of methyl.}}.$$

With pentachloride of phosphorus they produce chlorides of the formula $C^nH^{2n-1}OCl$; *e. g.*:—

$$\underbrace{C^2H^4O^2}_{\text{Acetic acid}} + PCl^5 = \underbrace{C^2H^3OCl}_{\text{Chloride of acetyl.}} + POCl^3 + HCl$$

Their alkaline salts distilled with arsenious anhydride give compounds of arsenic with the alcohol-radicles. (See ARSENIC.)

Subjected to electrolysis, they give carbonates, alcohol-radicles, hydrogen and hydrocarbons of the form C^nH^{2n} and C^nH^{2n+2}.

Under the influence of chlorine (or bromine) they lose one or more atoms of hydrogen, and take up in exchange an equivalent quantity of chlorine, forming chloracids whose general properties usually resemble closely those of the normal acids from which they are formed.

$$\underbrace{C^2H^4O^2}_{\text{Acetic acid.}} + Cl^2 = \underbrace{C^2H^3ClO^2}_{\text{Chloracetic acid.}} + HCl.$$

$$\text{,,} \quad + Br^4 = \underbrace{C^2H^2Br^2O^2}_{\text{Dibrom-acetic acid.}} + 2HBr.$$

$$\text{,,} \quad + Cl^6 = \underbrace{C^2HCl^3O^2}_{\text{Trichlor-acetic acid.}} + 3HCl.$$

b. Acids represented by the formula $C^nH^{2n}O^3$, di-atomic, but usually monobasic. The acids of this series differ from those of series *a* by containing three, instead of two, atoms of oxygen.

Carbonic acid	CH^2O^3,
Glycollic „	$C^2H^4O^3$,
Lactic „	$C^3H^6O^3$,
Butylactic „	$C^4H^8O^3$,
Valerolactic „ (Buttlerow)	$C^5H^{10}O^3$,
Leucic „	$C^6H^{12}O^3$.

These acids are formed

1°. By the reaction of the protochloro- or protobromo- derivatives of the acids of series *a* with hydrates.

$$\underbrace{C^2H^3ClO^2}_{\text{Chloracetic acid.}} + HKO = \underbrace{C^2H^4O^3}_{\text{Glycollic acid.}} + KCl.$$

2°. By the oxidation of the diatomic alcohols, $C^{n}H^{2n+2}O^{2}$ (glycols).

$$\underbrace{C^{2}H^{6}O^{2}}_{\text{Glycol.}} + O^{2} = \underbrace{C^{2}H^{4}O^{3}}_{\text{Glycollic acid.}} + H^{2}O.$$

3°. By the oxidation of certain amides of animal origin (glycocol and homologues), especially by nitrous acid.

$$\underbrace{C^{2}H^{5}NO^{2}}_{\text{Glycocol.}} + NHO^{2} = \underbrace{C^{2}H^{4}O^{3}}_{\text{Glycollic acid.}} + N^{2} + H^{2}O.$$

4°. By fermentation.

The acids of this series are decomposed by heat into anhydrides and water. (In the case of carbonic acid, this decomposition takes place at the ordinary temperature.)

With pentachloride of phosphorus, they produce diatomic chlorides of the formula $C^{n}H^{2n-4}OCl^{2}$; *e.g.*

$$\underbrace{C^{3}H^{6}O^{3}}_{\text{Lactic acid.}} + 2PCl^{5} = \underbrace{C^{3}H^{4}OCl^{2}}_{\text{Chloride of lactyl.}} + 2POCl^{3} + 2HCl$$

Lactic acid heated with hydriodic acid produces water, iodine and propionic acid (Lautemann):

$$\underbrace{C^{3}H^{6}O^{3}}_{\text{Lactic acid.}} + 2HI = \underbrace{C^{3}H^{6}O^{2}}_{\text{Propionic acid.}} + H^{2}O + I^{2}$$

This will probably be found to be a general method of converting acids of series *b* into the corresponding acids of series *a*.

c. Dibasic acids represented by the formula $C^{n}H^{(2n-2)}O^{4}$. The acids of this series represent the acids of series *b*, in which 2 at. hydrogen are replaced by an equivalent of oxygen.

Oxalic acid . . .	$C^{2}H^{2}O^{4}$	Pimelic acid . . .	$C^{7}H^{12}O^{4}$
Malonic „ . . .	$C^{3}H^{4}O^{4}$	Suberic „ . . .	$C^{8}H^{14}O^{4}$
Succinic „ . . .	$C^{4}H^{6}O^{4}$	Anchoic „ . . .	$C^{9}H^{16}O^{4}$
Lipic „ . . .	$C^{5}H^{8}O^{4}$	Sebacic „ . . .	$C^{10}H^{18}O^{4}$.
Adipic „ . . .	$C^{6}H^{10}O^{4}$		

These acids are, for the most part, products of oxidation. They are solid at ordinary temperatures, and are not volatile without partial or complete decomposition. Some of them are decomposed by heat into carbonic anhydride and a monobasic acid of series *a*.

$$\underbrace{C^{3}H^{4}O^{4}}_{\text{Malonic acid.}} = \underbrace{C^{2}H^{4}O^{2}}_{\text{Acetic acid.}} + CO^{2}.$$

Several of them also produce acids of series *a*, when fused with excess of alkaline hydrate; the reaction is accompanied by evolution of hydrogen (Gerhardt). Suberic and sebacic acids heated with a great excess of baryta, lose the elements of of 2 at. carbonic anydride and yield the hydrocarbons $C^{6}H^{14}$ and $C^{8}H^{18}$; it is probable that other acids of this series would be decomposed in like manner if similarly treated. (Riche.)

Pentachloride of phosphorus reacts on the acids of this series, producing at first the corresponding anhydrides, which are afterwards converted by excess of the chloride into chlorides of the formula $C^{n}H^{2n-4}O^{2}Cl^{2}$; *e. g.*

$$1°.\ \underbrace{C^{4}H^{6}O^{4}}_{\text{Succinic acid.}} + PCl^{5} = \underbrace{C^{4}H^{4}O^{3}}_{\text{Succinic anhydride.}} + 2HCl + POCl^{3}.$$

$$2°.\ \underbrace{C^{4}H^{4}O^{3}}_{\text{Succinic anhydride.}} + PCl^{5} = \underbrace{C^{4}H^{4}O^{2}Cl^{2}}_{\text{Chloride of succinyl.}} + POCl^{3}$$

There is a certain number of acids which do not enter into any of these three series, but which are related to certain members of them in the same way that the acids belonging to the different series are related to each other. For instance, glyoxylic acid, $C^{2}H^{4}O^{4}$, differs from glycollic acid, $C^{2}H^{4}O^{3}$, in the same way that the latter differs from acetic acid, $C^{2}H^{4}O^{2}$; namely, by containing one more atom of oxygen. And just as bromacetic acid when boiled with oxide of silver produces bromide of silver and glycollic acid —

$$\underbrace{C^{2}H^{3}BrO^{2}}_{\text{Bromacetic acid.}} + HAgO = \underbrace{C^{2}H^{4}O^{3}}_{\text{Glycollic acid.}} + AgBr$$

bromoglycollic acid, when similarly treated, yields bromide of silver and glyoxylic acid (Perkin and Duppa), —

$$\underbrace{C^2H^3BrO^3}_{\text{Bromoglycollic acid.}} + HAgO = \underbrace{C^2H^4O^4}_{\text{Glyoxylic acid.}} + AgBr.$$

Similarly, there is the same difference between glyceric acid, $C^3H^6O^4$, (homologous with glyoxylic acid) and lactic acid, $C^3H^6O^3$, that there is between lactic acid and propionic acid, $C^3H^6O^2$. Again, malic and tartaric acids, $C^4H^6O^5$ and $C^4H^6O^6$, differ from succinic acid by containing respectively one and two atoms more oxygen and they can be converted into succinic acid by heating them with hydriodic acid, in the same way that lactic acid can be converted into propionic acid (Schmidt); moreover, dibromosuccinic acid is decomposed, when boiled with oxide of silver, into bromide of silver and tartaric acid, just as dibromacetic acid is decomposed under similar circumstances into bromide of silver and glyoxylic acid (Perkin and Duppa). The same relation that exists between malic and succinic acids exists also between their homologues, tartronic and malonic acids $C^3H^4O^5$ and $C^3H^4O^4$, but in the case of these acids, the conversion of one into the other has not yet been effected. There is little doubt that these acids — glyoxylic and glyceric, tartronic and malic, and tartaric — represent homologous series running parallel with the three first described, but of which the other terms are as yet unknown.

The relation of all the series of acids, of which we have yet spoken, to each other and to the alcohols homologous with common alcohol, glycol, and glycerine, is shown in the following Table, giving the general formulæ of each series. It will be seen that of the formulæ written one above another, each contains one atom of oxygen more than the formula next above it, and that of the formulæ written in the same horizontal line, each contains two atoms of hydrogen less, and one atom of oxygen more, than the one directly to the left of it. Where known, a special illustration of each general formula is given.

	ALCOHOLS.	ACIDS.		
		Monobasic.		
Monatomic.	$C^nH^{2n+2}O$ Propylic, C^3H^8O.	$C^nH^{2n}O^2$ Propionic, $C^3H^6O^2$ and acids of series *a*.	$C^nH^{2n-2}O^3$ Pyruvic, $C^3H^4O^3$?	$C^nH^{2n-4}O^4$
			Dibasic.	
Diatomic.	$C^nH^{2n+2}O^2$ Propylic glycol, $C^3H^8O^2$.	$C^nH^{2n}O^3$ Lactic, $C^3H^6O^3$ and acids of series *b*.	$C^nH^{2n-2}O^4$ Malonic, $C^3H^4O^4$ Succinic, $C^4H^6O^4$ and acids of series *c*.	$C^nH^{2n-4}O^5$ Mesoxalic, C^3H^2O
Triatomic.	$C^nH^{2n+2}O^3$ Glycerin, $C^3H^8O^3$	$C^nH^{2n}O^4$ Glyceric, $C^3H^6O^4$	$C^nH^{2n-2}O^5$ Tartronic, $C^3H^4O^5$ Malic, $C^4H^6O^5$	Tribasic. $C^nH^{2n-6}O^6$.
Tetratomic.	$C^nH^{2n+2}O^4$	$C^nH^{2n}O^5$	$C^nH^{2n-2}O^6$ Tartaric, $C^4H^6O^6$	$C^nH^{2n-4}O^7$ Citric, $C^6H^8O^7$

Another series of acids is represented by the general formula $C^nH^{2n-2}O^2$. They are monobasic like the acids of series *a*, but differ from these by containing 2 atoms less hydrogen combined with the same quantity of carbon and oxygen. None of them have yet been very thoroughly investigated, and the empirical composition even of some of them is still open to discussion. The terms of this series hitherto more or less known are —

Acrylic acid . .	$C^3H^4O^2$	Campholic acid . .	$C^{10}H^{18}O^2$
Crotonic „ . .	$C^4H^6O^2$	Moringic „ . .	$C^{15}H^{28}O^2$
Angelic „ . .	$C^5H^8O^2$	Hypogæic „ . .	$C^{16}H^{30}O^2$
Pyroterebic „ . .	$C^6H^{10}O^2$	Oleic „ . .	$C^{18}H^{34}O^2$
Damaluric „ . .	$C^7H^{12}O^2$	Brassic „ . .	$C^{22}H^{42}O^2$

The following dibasic acids represented by the general formula $C^nH^{2n-4}O^4$, are related — so far at least as composition is concerned — to the last series, in the same manner as the acids of series *c* are related to those of series *a*.

Fumaric acid	$C^4H^4O^4$	Terebic	$C^7H^{10}O^4$
Citraconic Itaconic Mesaconic } acids	$C^5H^6O^4$	Camphoric	$C^{10}H^{16}O^4$

There are still two other series of acids, presenting the same mutual relations as the series *a* and *b*, several terms of which have been very fully studied. They are, —

1. Monobasic acids of the general formula $C^nH^{2n-8}O^2$.

Benzoic acid	$C^7H^6O^2$
Toluylic „	$C^8H^8O^2$
Cuminic „	$C^{10}H^{12}O^2$

2. Diatomic acids of the general formula $C^nH^{2n-8}O^3$.

Oxybenzoic acid	$C^7H^6O^3$
Oxytoluylic „	$C^8H^8O^3$
Phloretic „	$C^9H^{10}O^3$
Oxycuminic „	$C^{10}H^{12}O^3$

The position which a few of the yet remaining organic acids occupy in relation to the series already recognised can be indicated with tolerable certainty; but the greater number are still so imperfectly known that they cannot be included in any classification which is not entirely artificial and empirical. — G. C. F.

ACONITIC ACID. $C^6H^6O^6 = \left.\begin{matrix}(C^6H^3O^3)'''\\ H^3\end{matrix}\right\}O^3$ [or $C^{12}H^6O^{12}$]. *Equisetic acid, Citridic Acid.* (Gm. xii. 408; Gerh. ii. 110; iii. 960; iv. 922.)—An acid found in the roots and leaves of monkshood (*Aconitum Napellus*) and other aconites, and in the herb of *Delphinium Consolida*, collected after flowering. It is also produced by the metamorphosis of citric acid under the influence of heat. It exists in the aconite as aconitate of calcium, which crystallises out on evaporating the juice, and on account of its insolubility may by freed from the colouring matters and other impurities, by washing with water and alcohol. The aconitate of calcium is then dissolved in very dilute nitric acid, and the filtered liquid is precipitated with acetate of lead. The aconitate of lead, after being well washed, is decomposed by hydrosulphuric acid, the sulphide of lead filtered off, and the solution which contains the aconitic acid is evaporated to dryness, and the residue treated with ether, in which the acid dissolves, leaving the impurities.

To obtain it from citric acid, the acid is heated till it ceases to give off inflammable vapours; and the residue dissolved in alcohol is treated with hydrochloric acid, by which aconitic ether is formed, and separates on addition of water, as an oily liquid, which by treatment with potash is converted into aconitate of potassium. This salt is next converted into a lead salt, and the acid is liberated by hydrosulphuric acid as in the preceding process.

On evaporating the ethereal solution, it is left as an amorphous mass, very soluble in water, alcohol, and ether. When heated to 160° it is converted into an oily liquid, which is *itaconic acid*, $C^6H^6O^6 = C^5H^6O^4 + CO^2$. It is distinguished from fumaric acid by being more soluble in water, and from maleic acid by not crystallising.

Aconitic acid is tribasic, and forms three classes of salts, $C^6H^3M^3O^6$; $C^6H^3(M^2H)O^6$; and $C^6H^3(MH^2)O^6$, the first and third formulæ being doubled for salts of diatomic metals. The aconitates of ammonium, potassium, sodium, magnesium and zinc, dissolve readily in water; the rest are insoluble or sparingly soluble. The soluble aconitates form with solutions of lead and silver white flocculent precipitates, which do not become crystalline either by ebullition or after prolonged immersion in the liquid, whereas the lead and silver precipitates formed by fumaric and maleic acid are crystalline.

With *ammonium* and *potassium*, aconitic acid forms salts corresponding to each of the three formulæ above given; with *sodium*, a disodic and a trisodic salt. *Aconitate of calcium*, $C^{12}H^6Ca^3O^{12} + 6H^2O$? occurs in large quantity in extract of aconite. It may also be prepared by dissolving lime in aconitic acid, or by precipitating chloride of calcium with aconitate of sodium. It dissolves in 99 parts of cold water, more readily in boiling water. The solution evaporated at a gentle heat, and without agitation, yields a gelatinous mass which dries up to a gum; but if a few crystals of the salt be introduced into the solution, the whole is deposited in delicate crystals. *Aconitate of manganese*, $C^{12}H^6Mn^3O^{12} + 12H^2O$, is obtained by boiling the acid with carbonate of manganese. Small rose-coloured octahedrons, sparingly soluble in cold water. *Aconitate of lead*, $C^{12}H^6Pb^3O^{12} + 3H^2O$, is sparingly soluble in boiling water, and gives off 5·29 per cent. water at 140°.—*Aconitate of silver*, $C^6H^3Ag^3O^6$. Nitrate of silver is not precipitated by the free acid, but with the alkaline aconitates it forms a white, amorphous, sparingly soluble precipitate, which is partly reduced to the metallic state by boiling with water.

Aconitate of Ethyl, $C^6H^3(C^2H^5)^3O^6$, is prepared by dissolving aconitic acid in five times its weight of absolute alcohol, and saturating the solution with hydrochloric acid. On addition of water, the ether separates in the form of an oily layer.

It is a colourless liquid, having an aromatic odour, and very bitter taste. Boils at 236°, and has a density of 1·074, at 14°.

Aconitanilic acid or *Phenyl-aconitamic acid.* $C^{12}H^9NO^4 = O\left\{\begin{matrix}N(C^6H^3O^3)'''.C^6H^5\\H\end{matrix}\right.$ an amic acid formed on the type $O\left\{\begin{matrix}NH^4\\H\end{matrix}\right.$, three of the hydrogen-atoms in the ammonium being replaced by the triatomic radicle, aconityl, and the fourth by phenyl. It is obtained by the action of water on the (not yet isolated) compound, $C^{12}H^8NO^3Cl$, produced by treating citranilic (phenyl-citramic) acid with perchloride of phosphorus; probably thus:

$$\underbrace{C^{12}H^{11}NO^5}_{\text{Citranilic acid.}} + 2PCl^5 = C^{12}H^8NO^3Cl + 2POCl^3 + 3HCl;$$

and $$C^{12}H^8NO^3Cl + H^2O = C^{12}H^9NO^4 + HCl.$$

When 1 at. citranilic acid is mixed with 2 at. perchloride of phosphorus, added by small portions, and the action is assisted at intervals by a gentle heat, the whole dissolves, forming a yellow liquid; and on treating this liquid with water, hydrochloric acid is evolved, and aconitanilic acid separates in the form of a soft substance, which, by solution in hot water and cooling, may be obtained in small yellow needles, but cannot be rendered colourless even by repeated crystallisation. The acid dissolves sparingly in water, easily in alcohol, and very easily in aqueous ammonia; and the ammoniacal solution mixed with nitrate of silver, yields rose-coloured flakes of the *silver-salt*, $C^{12}H^8AgNO^4$. (Pebal, Ann. Ch. Pharm. xcviii. 83.)

Aconitodianil or *Diphenyl-aconito-diamide*, $C^{18}H^{14}N^2O^3 = N^2.(C^6H^3O^3.)'''(C^6H^5)^2.H$, is produced (together with aconitanilide), by the action of aconitic acid upon aniline:

$$C^6H^6O^6 + 2C^6H^7N = C^{18}H^{14}N^2O^3 + 3H^2O.$$

also by the action of oxychlorocitric acid upon aniline:

$$C^6H^8O^6Cl^2 + 2C^6H^7N = C^{18}H^{14}N^2O^3 + 3H^2O + 2HCl.$$

It is insoluble in water, very sparingly soluble in cold alcohol. From solution in a large quantity of boiling alcohol, it crystallises on cooling in slender, pale yellow needles. (Pebal.)

Aconitanilide or *Triphenyl-aconito-triamide*, $C^{24}H^{21}N^3O^3 = N^3(C^6H^3O^3)'''(C^6H^5)^3.H^3$, appears to be formed simultaneously with aconitodianil, by the action of aconitic acid or oxychlorocitric acid on aniline:

$$C^6H^6O^6 + 3C^6H^7N = C^{24}H^{21}N^3O^3 + 3H^2O$$

and $$C^6H^8O^6Cl^2 + 3C^6H^7N = C^{24}H^{21}N^3O^3 + 3H^2O + 2HCl.$$

It is an amorphous substance, insoluble in water, but very soluble in cold alcohol, and is thereby easily separated from aconito-dianil. (Pebal.)

The amides of aconitic acid have not yet been obtained.

ACONITINE. $C^{30}H^{47}NO^7$ [or $C^{60}H^{47}NO^{14}$]. (Geiger, Ann. Ch. Pharm. vii. 269; Morson, Pogg. xlii. 175; v. Planta, Ann. Ch. Pharm. lxxiv. 245.)—The alkaloid contained in the *Aconitum Napellus*, and probably in all the acrid aconites. It is obtained by exhausting the leaves with alcohol, saturating the extract with milk of lime, separating the lime by sulphuric acid, evaporating the filtered solution of sulphate of acontine at a gentle heat to expel the alcohol, then diluting with water, and treating the solution with carbonate of potassium, which precipitates impure aconitine. The product is purified by redissolving it in alcohol, treating the solution with animal charcoal, reconverting the base into sulphate, again decomposing this salt with hydrate of lime, and treating the precipitate with ether, which dissolves nothing but the aconitine.

Pure aconitine is deposited from solution in dilute alcohol in white pulverulent grains, or sometimes in a compact, vitreous, transparent mass. It is inodorous, but has a persistent, bitter, and acrid taste. It dissolves sparingly in cold water, and in 50 parts of boiling water, forming a strongly alkaline solution. It is very soluble in alcohol, less in ether. At 80° it melts into a vitreous mass, without loss of weight; at 120° it turns brown, and at a higher temperature suffers complete decomposition. It is dissolved without colour by nitric acid. Sulphuric acid colours it first yellow, then violet; tincture of iodine forms with it a kermes-coloured precipitate. It is intensely poisonous, $\frac{1}{50}$ of a grain sufficing to kill a sparrow in a few minutes, and $\frac{1}{10}$ of a grain killing it instantly.

The salts of aconitine do not crystallise readily. They are not deliquescent, but dissolve easily in water and alcohol. The solutions yield a precipitate of aconitine with alkalies. The *hydrochlorate*, $C^{30}H^{47}NO^7.2HCl$, is obtained by passing dry hydrochloric acid gas over dry aconitine. Its solution is not precipitated by chloride of platinum, but yields a white precipitate with chloride of mercury, yellow with chloride of gold, and also with picric acid.

ACONITYL. $C^6H^3O^3$; the triatomic radicle of aconitic acid and its derivatives.

ACRENE. A name given by Laurent to the hydrocarbon, C^3H^4. (See ALLYLENE.)

ACROLEIN. C^3H^4O [or $C^6H^4O^2$]. (Redtenbacher, Ann. Ch. Pharm. xlvii. 114; Geuther and Cartmell, ibid. cxii. 1; Hübner and Geuther, ibid. cxiv. 35; Gm. ix. 365; xii. 550; Gerh. i. iv. 779, 914.)—This body constitutes the acrid principle produced by the destructive distillation of fatty bodies, resulting in fact from the decomposition of glycerin. It is also produced by the action of platinum-black or of a mixture of acid chromate of potassium and sulphuric acid on allyl-alcohol, being indeed the aldehyde of the allyl series. (Cahours and Hofmann.) (See ALLYL.)

Acrolein is best prepared by distilling in a capacious retort a mixture of glycerin and acid sulphate of potassium, or phosphoric anhydride. When phosphoric anhydride is used, the distillate consists entirely of acrolein; but the contents of the retort are very apt to froth over. With acid sulphate of potassium, the distillation is easier, but the acrolein is contaminated with acrylic acid, sulphurous acid, and other products. The distillate is collected in a receiver kept very cold, and provided with a long discharge-tube passing into the chimney in order to carry off the vapours, which are intensely irritating to the eyes. To purify the acrolein, it is digested with oxide of lead, which removes the acid impurities, then rectified in the water-bath, dehydrated over chloride of calcum, and again rectified. As acrolein oxidises very rapidly by contact with the air, all these operations must be conducted with a stream of dry carbonic acid gas passing through the apparatus. (Redtenbacher.)

Hübner and Geuther distil 1 pt. of glycerin with 2 pts. of acid sulphate of potassium, over an open flame, the bottom of the flask being protected by wire-gauze, and a quantity of oxide of lead being placed in the receiver to neutralise the acid products. According to these chemists, the process consists of two stages, the acid sulphate of potassium first dissolving in the glycerin, forming glycerosulphate of potassium, with elimination of water, so that the first portion of the distillate consists chiefly of water, with but little acrolein; but, afterwards, when the liquid becomes more concentrated, the glycerosulphate is decomposed, and acrolein passes over with only a small quantity of water. This latter portion of the distillate is subsequently purified as in Redtenbacher's process.

Acrolein is a colourless, limpid, strongly refracting liquid, lighter than water, and boiling at 52°4 (Hübner and Geuther). Vapour-density 1·897. Its vapour is so intensely irritating, that a few drops diffused through a room are sufficient to render the atmosphere insupportable. It burns readily with a clear bright flame. It dissolves in about 40 parts of water, and very readily in ether. The solutions are neutral at first, but gradually turn acid by contact with the air.

Acrolein cannot be preserved long, even in closed vessels, as it changes spontaneously into a flocculent substance called by Redtenbacher *disacryl*, and more rarely into a resinous substance, *disacryl-resin*. It sometimes solidifies immediately after being prepared, even in sealed tubes. It undergoes the same transformation under water, which at the same time becomes charged with acrylic, formic and acetic acids. Vapour of acrolein passed through a red-hot tube is decomposed, with formation of water and deposition of charcoal.

Caustic alkalis convert acrolein into resinous products. By *oxidising agents* it is converted into acrylic acid. It reduces oxide of silver with considerable evolution of heat, forming acrylate of silver, which remains dissolved. Nitrate of silver forms with aqueous acrolein a white curdy precipitate (probably C^3H^3AgO) which, however, gradually decomposes, yielding metallic silver and acrylate of silver. On adding a few drops of ammonia, and boiling the liquid, the silver is immediately reduced, but not in the specular form as with aldehyde. *Nitric acid* attacks acrolein strongly, converting it into acrylic acid. *Strong sulphuric acid* blackens it, giving off sulphurous anhydride at the same time. With *chlorine* and *bromine*, it forms heavy oils, together with hydrochloric or hydrobromic acid. *Perchloride of phosphorus* acts violently on acrolein, forming dichloride of allylene $C^3H^4.Cl^2$ (see ALLYLENE), and another oily liquid which appears to be isomeric with it. With *acetic anhydride*, it unites directly, forming the compound $C^3H^4O.C^4H^6O^3$, which is identical in every respect with the compound resulting from the action of acetate of silver on dichloride of allylene (Hübner and Geuther), and may therefore be regarded as diacetate of allylene $(C^3H^4)''.(C^2H^3O)^2.O^2$.

Acrolein-ammonia. $C^{12}H^{20}N^2O^3 = C^{12}H^{18}N^2O^2.H^2O$. Acrolein acts strongly on ammonia, forming a solid compound (first obtained by Redtenbacher):

$$4C^3H^4O + 2NH^3 = C^{12}H^{20}N^2O^3 + H^2O.$$

It is best prepared by gradually adding a saturated solution of ammonia-gas in alcohol to an alcoholic or ethereal solution of acrolein, and precipitating by addition of ether. It is a white or yellowish, amorphous, odourless compound which turns brown at a gentle heat and begins to decompose at 100°, giving off volatile basic products. In the moist state it dissolves readily in cold water and warm alcohol; less in hot water. It dissolves readily in acids, and is precipitated therefrom by alkalis and alkaline carbonates. Hence it appears to be a base. Its solution in hydrochloric acid forms with tetrachloride of platinum, a light yellow precipitate containing, when dried at 100°, $C^{12}H^{18}N^2O^2.2HCl.PtCl^4$, or $2(C^6H^9NO.HCl).PtCl^4$. (Hübner and Geuther.)

Acrolein with Acid Sulphite of Sodium.—When acrolein is poured into in aqueous solution of acid sulphite of sodium, its odour is destroyed, and by evaporation over the water-bath, a brown deliquescent syrup is obtained which does not deposit crystals, and from which neither acrolein can be separated by boiling with carbonate of sodium, nor sulphurous acid by boiling with sulphuric acid. (Hübner and Geuther.)

Hydrochlorate of Acrolein, $C^3H^4O.HCl$. Produced by passing dry hydrochloric acid gas into anhydrous acrolein in a vessel surrounded by cold water. The viscid product, washed and dried over oil of vitriol in vacuo, yields hydrochlorate of acrolein as a mass of velvety crystals, which melt at 32° into a thick oil, having the odour of rancid fat. It is insoluble in water, but readily soluble in alcohol and ether, on the evaporation of which it remains as a thick oil. It is resolved by heat into acrolein and hydrochloric acid. It is not apparently altered by boiling with water, or by the action of dilute solutions of the alkalis. Heated with ammonia to 100° in a sealed tube, it yields chloride of ammonium and acrolein-ammonia. Strong hydrochloric acid decomposes it, setting the acrolein free; a similar action is exerted by dilute sulphuric or nitric acid. Hydrochlorate of acrolein in alcoholic solution does not combine with dichloride of platinum, and very slowly reduces a boiling ammoniacal solution of nitrate of silver.

Gaseous *hydriodic acid* passed into acrolein exerts a violent action, attended with a hissing noise like that of red-hot iron plunged into water. The product is a resinous body which is insoluble in alcohol, ether, acids and alkalis, gives off iodine when heated, and yields a small quantity of free iodine to bisulphide of carbon.

METACROLEIN. Hydrochlorate of acrolein heated with hydrate of potassium gives off hydrogen, and yields an oily distillate, which solidifies in magnificent colourless, needle-shaped crystals, consisting of metacrolein, a compound isomeric or more probably polymeric with acrolein. It is lighter than water, has an aromatic odour, and a cooling taste with burning after-taste. It melts at 50°, solidifies at about 45°, or volatilises a little before melting, so that it may be distilled with vapour of water. By heat, it is changed into common acrolein. It is not affected by dilute alkalis, but when heated with mineral acids it is changed more or less into acrolein. In a stream of dry hydrochloric acid gas, it melts and is converted into the hydrochlorate of acrolein above described. Hence it is probable that the compound so named is really a *hydrochlorate of metacrolein*, perhaps $C^6H^8O^2.2HCl$.

Hydriodate of Metacrolein is produced by passing dry hydriodic acid gas over metacrolein, as a heavy yellow liquid which resembles the hydrochlorate in taste and appearance, and after washing in water, shows a tendency to crystallise at ordinary temperatures. When placed over oil of vitriol, it decomposes, turning brown and giving off iodine.

Hydriodic acid gas acts violently upon acrolein, producing a resinous substance which is insoluble in alcohol, ether, acids and alkalis, and gives up iodine when heated or when digested with bisulphide of carbon. (Geuther and Cartmell.)

ACRYLIC ACID. $C^3H^4O^2 = C^3H^3O.HO$ (or $C^6H^4O^4$). (Gm. ix. 369; Gerh. 783; iv. 914.) *Acroleic acid.* This acid, discovered by Redtenbacher, is produced by the oxidation of acrolein. The best agent to employ is oxide of silver, which, when digested with acrolein, yields a deposit of metallic silver, and a solution of acrylate of silver. This salt is decomposed by hydrosulphuric acid, and the acrylic acid thus set free is purified by rectification. It is necessary carefully to cool the vessel during the decomposition of the silver salt; otherwise, the heat developed is so great that an explosion results. The acid is likewise obtained by the action of chromic acid on oxide of allyl. (Hofmann and Cahours.) (See ALLYL.)

When purified, it is a colourless liquid, of an agreeable, slightly empyreumatic odour. It is miscible with water in all proportions, and its boiling-point is intermediate between that of formic and acetic acids.

It is a monobasic acid, its salts having the formula, $C^3(H^3M)O^2$. They closely resemble the formates and acetates, and are generally very soluble in water.

Acrylate of Sodium. $2C^3(H^3Na)O^2 + 5H^2O$, is obtained by saturating the acid with carbonate of sodium and evaporating. It crystallises in transparent prisms.

Acrylate of Barium. $C^6(H^6Ba'')O^4$, is also a soluble salt.

Acrylate of Silver, $C^2(H^3Ag)O^2$, forms white needles, having a silky lustre, and very soluble in water.

Acrylate of Ethyl is obtained, though not in the pure state, by distilling acrylic acid, or its sodium or barium-salt with alcohol and sulphuric acid. (Redtenbacher.)

ACTINOLITE. A variety of Hornblende (*q. v.*)

ADAMANT. See DIAMOND. — **ADAMANTINE SPAR.** See CORUNDUM.

ADAPTER or **ADOPTER.** A piece of tube of more or less conical form, used to elongate the neck of a retort, and to connect it with a receiver.

ADHESION. (See COHESION.)

ADHESIVE SLATE. (See SLATE.)

ADIAPHANOUS SPAR. (See GEHLENITE and SAUSSURITE.)

ADINOLE. A compact impure felspar, better known as *petrosilex*. It differs from jaspar, which it otherwise much resembles, in being fusible before the blowpipe.

ADIPIC ACID. $C^6H^{10}O^4 = O^2\left\{\begin{matrix}C^6H^8O^2\\ H^2\end{matrix}\right.$, [or $C^{12}H^{10}O^8 = C^{12}H^8O^6.2HO$]. A dibasic acid forming the fifth term of the series $C^nH^{2n-2}O^4$ the lowest term of which is oxalic acid, $C^2H^2O^4$, and the highest at present known, sebacic acid, $C^{10}H^{18}O^4$. It is produced by the action of nitric acid on oleic acid, suet, spermaceti, and other fatty bodies. To prepare it, tallow or suet is boiled in a capacious retort with nitric acid of ordinary strength, which must be frequently renewed, and the distillate poured back till the fatty matter disappears and crystals separate on cooling. The liquid is then evaporated over the water-bath till it solidifies in a crystalline mass on cooling; this mass is washed in a funnel, first with strong nitric acid, then with dilute nitric acid, and lastly with cold water; and the acid is finally purified by crystallisation from boiling water (Malaguti). Other acids of the same series are doubtless formed at the same time; but according to Malaguti, the crystals obtained in the manner just described have all the same appearance, excepting the very last. Wirz (Ann. Ch. Pharm. civ. 257) obtains this acid, together with several other members of the series, by the continued action of nitric acid on the solid fatty acids of cocoa-nut oil. The action is continued for several weeks till the mass solidifies to a crystalline magma. This product is resolved by water into a mixture of several acids of the above series, and a heavy oil; and the acids are separated one from the other by fractional crystallisation from water and alcohol, and lastly by fractional crystallisation of the silver-salts. (See ANCHOIC ACID.)

The acid separates from its aqueous solution in crystalline crusts composed of soft, white, opaque, hemispherical nodules, which appear to be aggregations of smaller crystals. According to Wirz, these crystals dried at 100° contain water of crystallisation, their formula being $2C^6H^{10}O^4 + H^2O$ [anal. 46·2, 46·4 and 47·8 p. c. carbon, 6·6 and 6·8 p. c. hydrogen; calc. 46·4 C and 7·0 H]. At 140° they melt and give off water, leaving the anhydrous acid $C^6H^{10}O^4$ [analysis, 48·2, and 48·3 C; 6·8 and 6·9 H; calc. 49. 3 C and 6·8 H]; which soon afterwards sublimes in long slender needles [the sublimed acid gave by analysis 49·5 C and 6·6 H].

100 parts of water at 18° dissolve 7·73 of the crystallised acid: a hot solution which deposited crystals abundantly on cooling, still retained 8·61 pts. of the acid in 100 pts. at 18° (Wirz). The acid dissolves very readily in hot *alcohol* and *ether*.

The *adipates*, $C^6H^8M^2O^4$, are for the most part soluble in water and crystallisable; insoluble in alcohol. The *ammonium*-salt crystallises in needles (Laurent, Bromeis). The *barium*-salt dried over sulphuric acid, forms opaque warty masses not containing water of crystallisation (Wirz). The *strontium*-salt forms microscopic needles containing $2C^6H^8Sr''O^4 + 3H^2O$ (Laurent). The *calcium-salt* resembles the barium-salt in appearance, but contains 1 atom of water [$C^6H^8CaO^4 + H^2O$] which is given off between 100° and 200° (Wirz). The *silver-salt*, $C^6H^8Ag^2O^4$, obtained by precipitating the ammonium-salt with a considerable quantity of nitrate of silver, is a white powder.

Adipate of Ethyl, $C^6H^8O^4(C^2H^5)^2$, obtained by saturating the alcoholic solution of the acid with hydrochloric acid gas, is a yellowish oil of sp. gr. 1·001 at 20·5° which boils, with decomposition, at 230°. It has a strong odour of apples and a bitter caustic taste. Chlorine decomposes it, giving off hydrochloric acid and forming a viscous mass. (Malaguti.)

ADIPOCERE. (From *adeps*, fat; and *cera*, wax.) A peculiar white substance, produced by the decomposition of animal matters under the influence of moisture and in situations from which the air is excluded. It was first found by Fourcroy in the *Cimetière des Innocents* at Paris. A number of coffins had been piled one upon another, and remained interred for about 20 years. The bodies were found compressed, as it were, at the bottom of the coffins, and converted into a soft white substance resembling cheese, which bore the imprints of the linen in which they had been wrapped. This matter enclosed the bones, which were broken on the slightest pressure. It was found to consist chiefly of margarate of ammonium together with the margarates of potassium and calcium.

ADULARIA. (See FELSPAR.)

AEDELFORSITE. (See EDELFORSITE.)

AEGIRIN or **AEGYRIN.** (Handwört. d. Chem. i. 169.) A mineral of the augite family, occurring in the neighbourhood of Brevig in Norway, sometimes in very large and well-defined crystals belonging to the monoclinic system, and having the general character and cleavage of augite. Colour greenish-black to leek-green. Lustre vitreous. The edges exhibit various degrees of translucence, down to complete opacity. Sp. gr. 3·43 to 3·50. Hardness about that of orthoclase. The mineral contains a considerable quantity of iron, partly in the state of protoxide, partly of sesquioxide, besides alumina, lime, magnesia, and soda, sometimes also protoxide of manganese and potash, associated with silica, and sometimes with titanic acid. The formula is not perfectly established, but it is probably of the general form,

$$3(M^2O.SiO^2) + n(M^4O^3.3SiO^2) = 3M^2SiO^3 + nM^4Si^3O^9$$

AERATED WATERS. (See CARBONIC ACID and WATER.)

AEROLITE. (See METEORITE.)—**AEROSITE.** (See PYRARGYRITE.)

AESCHYNITE. (Handwört. d. Chem. i. 192.) A mineral occurring at Miask in the Ural, and consisting, according to Hartwall's analysis, of 56 titanic acid, 20 zirconia, 15 ceric oxide, 3·8 lime, 2·6 ferric oxide, 0·5 stannic oxide (making together 97·9), but according to Hermann's more recent analysis, of 25·90 titanic acid, 33·20 columbic acid, 22·20 ceric oxide, 5·12 cerous oxide, 5·45 ferrous oxide, 6·22 oxide of lanthanum, 1·28 yttria, and 1·20 water (= 100·57). By its crystalline form and properties, as well as by its chemical constitution, it appears to be closely related to Polymignite, Polycrase, Euxenite, &c.

AESCULETIN or **ÆSCULETIN.** $C^9H^6O^4$, or $C^{18}H^6O^8$. A product of the decomposition of æsculin, discovered in 1853 by Rochleder and Schwartz (Ann. Ch. Pharm. lxxxvii. 186; lxxxviii. 356), and independently by Zwenger (ib. xc. 63). It is obtained; 1. By boiling æsculin with hydrochloric or dilute sulphuric acid. The liquid on cooling deposits a crystalline mass which, when washed with cold water, dissolved in hot alcohol, and treated with acetate of lead, yields a lead-compound of æsculetin from which the latter may be separated by hydrosulphuric acid.—2. A cold saturated solution of æsculin mixed with emulsin (the fermenting principle of sweet almonds) and left in a warm place, deposits after a while, small crystals of æsculetin.

Æsculetin forms shining needles or scales which are bitter, sparingly soluble in cold water and alcohol, more soluble in the same liquids when warm, but nearly insoluble in ether. The aqueous solution is fluorescent like that of æsculin (*q. v.*), but in a much less degree; the fluorescence is however considerably exalted by addition of a small quantity of carbonate of ammonium.

When gradually heated, it gives off 6·64 p.c. water at 100, melts above 270°, and then distils with decomposition. Hydrochloric acid dissolves it without alteration; nitric acid converts it into oxalic acid. It is also decomposed by hot concentrated sulphuric acid. It dissolves in alkalis, forming solutions of a fine gold-yellow colour; its solution in boiling aqueous ammonia deposits on cooling a yellow substance, which decomposes rapidly in contact with the air. Æsculetin imparts a dark green colour to ferric salts. It reduces nitrate of silver at the boiling heat; precipitates red oxide of copper from cupric salts dissolved in potash; and forms with acetate of lead a yellow precipitate containing $C^9H^4Pb''O^4$.

AESCULIC ACID. Obtained as a white precipitate by boiling *saponin* (a substance contained in the horse-chesnut and in many other plants) with dilute hydrochloric or sulphuric acid, or by boiling saponin with potash-ley and decomposing the resulting æsculetate of potassium with an acid. It is insoluble in water, but soluble in alcohol, and is deposited therefrom in granular crystals on cooling. Nitric acid transforms it into a yellow resinous nitro-compound. It is but a weak acid. The alkaline æsculates are soluble in water, and crystallise from solution in alcohol. The formula of æsculic acid, according to Fremy (Ann. Ch. Phys. [3] lviiii. 101) is $C^{26}H^{46}O^{12}$. Bolley (Ann Ch. Pharm. xc. 211), who calls it *sapogenin*, assigns to it the formula $C^{12}H^{18}O^{5}$. According to Rochleder and Schwarz (Ann. Ch. Pharm. lxxxviii. 357) it is identical with *chinovatic acid* $C^{6}H^{10}O^{2}$.

AESCULIN or **ESCULIN.** $C^{21}H^{24}O^{13}$, or $C^{42}H^{24}O^{26}$. (Gerh. iv. 291, Handwört. d. Chem. i. 196.) A crystalline fluorescent substance obtained from the bark of the horse-chestnut (*Aesculus Hippocastanum*) and of other trees of the genera *Aesculus* and *Pavia*. It was first observed by Frischmann, more closely investigated by Trommsdorff the younger in 1835 (Ann. Ch. Pharm. xiv. 198), afterwards by Rochleder and Schwarz (ibid. lxxxvii. 186; lxxxviii. 156), and by Zwenger (ibid. xc. 63).

The aqueous extract of the bark is precipitated with acetate of lead; the precipitate is washed, suspended in water, and decomposed by hydrosulphuric acid; and the liquid is filtered at the boiling heat. Or better: the aqueous extract is mixed with solution of alum and excess of ammonia; the liquid filtered to separate the fawn-coloured precipitate of alumina mixed with the colouring matter of the bark; the yellowish filtrate neutralised with acetic acid and evaporated to dryness; the residue containing the sulphates and acetates of potassium and ammonium, boiled with a little strong alcohol to extract the æsculin; the alcoholic filtrate evaporated till it crystallises; and the æsculin thus obtained, is purified by pressure between bibulous paper, and recrystallisation. (Rochleder, J. pr. Chem. lxxi. 414; Chem. Gaz. 1858, 96.)

Aesculin forms colourless, needle-shaped crystals. It is inodorous, has a bitter taste, is sparingly soluble in cold water and alcohol, more soluble in the same liquids at the boiling heat, and nearly insoluble in ether.

Aesculin is coloured red by chlorine; it forms a yellow precipitate with subacetate of lead, and reduces the protoxide of copper to suboxide, like glucose. It melts at 160° and decomposes at a somewhat higher temperature, yielding various products among which is a small quantity of æsculetine. Boiled with hydrochloric or dilute sulphuric acid, it is resolved into æsculetin and glucose:

$$C^{21}H^{24}O^{13} + 3H^{2}O = C^{9}H^{6}O^{4} + 2C^{6}H^{12}O^{6}$$

The aqueous solution of æsculin is highly fluorescent (see LIGHT), the reflected light being of a sky-blue colour. Nearly the same fluorescent tint is exhibited by an infusion of horse-chestnut bark. The colour is however slightly modified by the presence of another fluorescent substance, *paviin*, recently discovered by Prof. Stokes (Chem. Soc. Qu. J. xi. 17). The latter is separated from æsculin by its greater solubility in ether. Its solution exhibits a blue-green fluorescence. Aesculin and paviin appear to exist together in the barks of all species of the genera *Asculus* and *Pavia*, æsculin being however more abundant in the former and paviin in the latter (see PAVIIN). The fluorescence of both æsculin and paviin is augmented by alkalis, but destroyed by acids.

AETHAL. (See CETYL.)

AETHER, AETHYL, &c. (See ETHER, ETHYL, &c.)

AETHIOPS. An old pharmaceutical term applied to various mineral preparations of black colour or approaching thereto: *e. g. Aethiops antimonialis* obtained by triturating together mercury, sulphide of antimony, and sulphur; *Aethiops martialis* black oxide of iron; *Aethiops mineralis*, black sulphide of mercury obtained by triturating mercury with sulphur; *Aethiops narcoticus* (or *hypnoticus*,) sulphide of mercury obtained by precipitation; *Aethiops per se*, the grey powder obtained by exposing impure mercury to the air.

AETHOXIRRHIN. The yellow colouring matter of the flowers of *Antirrhinum Linaria*.

AFFINITY. (See CHEMICAL AFFINITY.)

AFTONITE. (See APHTONITE.)

AGALMATOLITE [from ἄγαλμα, an image; and λίθος, stone]; *Bildstein*. This name was originally given to a soft mineral or rather a number of such minerals used by the Chinese for carving grotesque figures and idols. These minerals vary in colour from greyish-green to yellow and red; they are all more or less soft and unctuous to the touch and capable of being cut and polished.

The Chinese agalmatolites are of three kinds: viz.

1. Hydrated silicates of aluminium and potassium:

$$a.\ 9SiO^{2}.3Al^{2}O^{3}.1K^{2}O.3H^{2}O = 6\mathit{SiO^{3}.3Al^{2}O^{3}.1KO.3HO}$$
$$b.\ 3SiO^{2}.1Al^{2}O^{3}.M^{2}O.1H^{2}O = 6\mathit{SiO^{3}.3Al^{2}O^{3}.3MO}^{*}\mathit{.3HO}$$

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* M denotes potassium, sodium, calcium, magnesium, &c. Si = 28; *Si* = 21.

2. Hydrated silicates of aluminium.

$$a.\ 9SiO^2.2Al^2O^3.6H^2O = 3SiO^3.1Al^2O^3.3HO$$
$$b.\ 15SiO^2.4Al^2O^3.4H^2O = 5SiO^3.2Al^2O^3.2HO$$

3. Hydrated silicates of magnesium:

$$15SiO^2.12Mg''O.4H^2O = 5SiO^3.6MgO.2HO$$

There are also several European minerals which in composition and physical character closely resemble the Chinese agalmatolites.

4. Agalmatolite from Magyag in Hungary has the same composition as the Chinese mineral, 1, *a*.

5. Agalmatolite, from Ochsenkopf in the Saxon Harz, and *Onkosin* from Posseggen in Salzburg, have a composition expressed by the formula:

$$9SiO^2.3Al^2O^3.2M^2O.3H^2O = 6SiO^3.3Al^2O^3.2MO.3HO.$$

6. *Mother of Diaspore*, a mineral in which the diaspore of Schemnitz in Hungary is intergrown, has the composition 2, *a* above.

7. *Parophite* from Canada has a composition corresponding to the formula:

$$9SiO^2.3Al^2O^3.3M^2O.4\tfrac{1}{2}H^2O = 6SiO^3.3Al^2O^3.MO.4\tfrac{1}{2}HO$$

8. *Dysyntribite*, from Diana and other localities in St. Lawrence county, New York, appears also to have a constitution resembling that of the agalmatolites.

9. *Kaolin*, which is a hydrated silicate of aluminium, containing

$$(2SiO^2.Al^2O^3.2H^2O) = 4SiO^3.3Al^2O^3.6HO,$$

exactly resembles the agalmatolites in physical character.

10. *Neolite*, from Eisenach and other localities, containing

$$9SiO^2.Al^2O^3.3M^2O.H^2O = 6SiO^3.1Al^2O^3.3MO.1HO,$$

also forms masses resembling agalmatolite.

All these minerals have a specific gravity ranging from 2·75 to 2·85; rarely as high as 2·90. In hardness, they are intermediate between gypsum and calcspar. They are more or less translucent, unctuous to the touch, do not adhere to the tongue, and are easily carved and wrought.

The true agalmatolites are 1, *a*; 4, 5, 6, and 7: the rest may be regarded as allied species. (Handw. d. Chem. i. 375.)

AGAPHITE. (See TURQUOISE.)

AGAR-AGAR, or Bengal Isinglass: a dried sea-weed from Singapore, consisting of small transparent colourless strips, is almost completely soluble in water, and forms a large quantity of thick, tasteless, and odourless jelly.

AGARICIN. (See AMANITIN.)

AGARICUS. A genus of the order *Fungi*. Many fungi, especially of the genus *Agaricus* are commonly used as food, and it is remarkable that the amount of nitrogen contained in their dried substance exceeds that in peas and beans, which are generally regarded as the most nutritious of all articles of food.

The following table exhibits the percentage of nitrogen and of ash in various species of fungi, as determined by Schlossberger and Döpping (Ann. Ch. Pharm. lii. 106 to 120). The plants were dried at 100° C. The quantity of water averaged about 90 per cent.

	Nitrogen.	Ash.
Agaricus deliciosus	4·68	6·9
„ *arvensis*	7·26	19·82
„ *glutinosus*	4·61	4·8
„ *russula*	4·25	9·5
„ *cantharellus*	3·22	11·2
„ *muscarius*	6·34	9·9
Boletus aureus	4·7	6·80
Lycoperdon echinatum	6·16	5·2
Polyporus fomentarius	4·46	3·0
Dædalea quercina	3·19	3·1

The ash contains a large proportion of phosphates. The solid tissue of fungi, formerly regarded as a peculiar substance, *fungin*, is nothing but cellulose: it may be extracted by treating the fungi successively with water, weak soda-ley, hydrochloric acid, and alcohol. Agarics were found by Schlossberger and Döpping to contain mannite and fermentable sugar, but no starch. The acid contained in agarics and other fungi was formerly supposed to be of peculiar nature, and called *boletic* or *fungic* acid; but it has been shown by Bolley and Dessaignes that many agarics contain fumaric acid, sometimes associated with malic, citric, and phosphoric acid.

AGARICUS MINERALIS, the *mountain milk*, or *mountain meal*, of the Germans, is one of the purest of the native carbonates of lime, found chiefly in the clefts of rocks, and at the bottom of some lakes, in a loose or semi-indurated form.

The name of *mineral agaric*, or *fossil meal*, was also applied by Fabroni to a stone of a loose consistence found in Tuscany in considerable abundance, of which bricks may be made, either with or without the addition of a twentieth part of clay, so light as to float in water, and which he supposes the ancients used for making their floating bricks. This, however, is very different from the preceding, not being even of the calcareous genus, since it appears, on analysis, to be a hydrated silicate of magnesium mixed with lime, alumina, and a small quantity of iron. Kirwan calls it *argillo-murite*.

AGATE. A mineral, whose basis is calcedony, blended with variable proportions of jasper, amethyst, quartz, opal, heliotrope, and carnelian. *Ribbon agate* consists of alternate and parallel layers of calcedony with jasper, or quartz, or amethyst. The most beautiful comes from Siberia and Saxony. It occurs in porphyry and gneiss.—*Brecciated agate;* a base of amethyst, containing fragments of ribbon agate, constitutes this beautiful variety; it is of Saxon origin.—*Fortification agate*, is found in nodules of various imitative shapes, imbedded in amygdaloid. This occurs at Oberstein on the Rhine, and in Scotland. On cutting it across and polishing it, the interior zig-zag parallel lines bear a considerable resemblance to the plan of a modern fortification. In the very centre, quartz and amethyst are seen in a splintery mass, surrounded by the jasper and calcedony.—*Mocha stone.* Translucent calcedony, containing dark outlines of arborisation, like vegetable filaments, is called Mocha stone, from the place, in Arabia, where it is chiefly found. These curious appearances were ascribed to deposits of iron or manganese, but more lately they have been thought to arise from mineralised plants of the cryptogamous class.—*Moss agate*, is a calcedony with variously coloured ramifications of a vegetable form, occasionally traversed with irregular veins of red jasper. Dr. M'Culloch has detected, what Daubenton merely conjectured, in mocha and moss agates, aquatic confervæ, unaltered both in colour and form, and also coated with iron oxide. Mosses and lichens have also been observed, along with chlorite, in vegetations. An onyx agate set in a ring, belonging to the Earl of Powis, contains the chrysalis of a moth.

Agate is found in most countries, chiefly in trap rocks and serpentine. Hollow nodules of agate, called *geodes*, present interiorly crystals of quartz, colourless or amethystine, having occasionally scattered crystals of stilbite, chabasite, and capillary mesotype. These geodes are very common. Bitumen has been found by M. Patrin in the inside of some of them, among the hills of Dauria, on the right bank of the Chilca. The small geodes of volcanic districts occasionally contain water in their cavities. These are chiefly found in insulated blocks of a lava having an earthy fracture. When they are cracked, the liquid escapes by evaporation; it is easily restored by plunging them for a little in hot water. Agates are artificially coloured by immersion in metallic solutions. Agates were more in demand formerly than at present. They were cut into cups and plates for boxes; and also into cutlass and sabre handles. They are still cut and polished on a considerable scale and at a moderate price, at Oberstein. The surface to be polished is first coarsely ground by large millstones of a hard reddish sandstone, moved by water. The polish is afterwards given on a wheel of soft wood, moistened and imbued with a fine powder of a hard red *tripoli* found in the neighbourhood. M. Faujas thinks that this *tripoli* is produced by the decomposition of the porphyrated rock which serves as a gangue to the agates. The ancients employed agates for making cameos (see CALCEDONY). Agate mortars are valued by analytical chemists, for reducing hard minerals to an impalpable powder.

The oriental agate is almost transparent, and of a vitreous appearance. The occidental is of various colours, and often veined with quartz or jasper. It is mostly found in small pieces covered with a crust, and often running in veins through rocks like flint and petrosilex, from which it does not seem to differ greatly. Agates are most prized when the internal figure nearly resembles some animal or plant.—U.

AGEDOIL. A name applied by Caventou to a crystallisable substance obtained from liquorice-root; identical with asparagin. (Henry and Plisson.)

AGNESITE. Syn. with BISMUTITE.

AGROSTEMMINE. A crystalline basic substance obtained from the seeds of the corn-cockle (*Agrostemma Githago*). The seeds are exhausted with weak alcohol acidulated with acid; the acid is concentrated by evaporation and mixed with magnesia; and the dried precipitate is treated with alcohol.

Agrostemmin crystallises in pale yellow scales which are but slightly soluble in water, but very soluble in alcohol, to which they impart an alkaline reaction. It is decomposed by boiling potash, with evolution of ammonia.

The sulphate, chloro-aurate and chloroplatinate of agrostemmine are crystallisable; the phosphate forms a bulky precipitate. (**Schulze**, Ann. Ch. Pharm. lxviii. 350.)

AIKINITE. Syn. with ACICULITE.

AIR. The term "air" (Latin, *aer*) is now exclusively employed to denote the component gases of the earth's atmosphere. Amongst the older writers on science, we find the word "air" made use of to designate the gaseous or aeriform condition of a body; thus carbonic acid gas was called "fixed air," hydrochloric acid gas "marine acid air," hydrogen gas "inflammable air," &c. (See ATMOSPHERE.)

AJUGA REPTANS (*Creeping Bugle*). (Handw. d. Chem. i. 385.) This plant, grown on the even ground of the Lechthal, yielded, when gathered in the beginning of June, 84·3 p.c. water, and 10·4 p.c. ash (*a*); that which grew on the chain of hills adjoining the valley, yielded at the end of June, 81·6 p.c. water and 9·5 p.c. ash (*b*).

	a.	*b.*
Potash	37·31	36·39
Soda	—	4·81
Lime	23·73	15·70
Magnesia	10·70	5·43
Sesquioxide of iron	2·79	1·70
Manganoso-manganic oxide	trace	2·29
Phosphoric anhydride	5·46	5·51
Sulphuric	3·63	3·68
Chloride of potassium	5·04	—
Chloride of sodium	2·66	2·78
Silica	8·61	21·71

AKANTICON. (See EPIDOTE.)

AKCETHIN. (See ACETONE.)

AKMITE. (See ACHMITE.)

AKONTITE. A variety of arsenical pyrites.

ALABANDIN. (See MANGANESE-GLANCE.)

ALABASTER. *Granular gypsum*, *Albâtre gypseux*. The technical name for granular gypsum or sulphate of calcium. Alabaster is among the several varieties of gypsum what marble is among carbonates of calcium, and like marble is used for sculpture, especially for objects of small dimensions. The hard, fine-grained, snow-white, translucent alabaster from Volterra near Florence, is especially valued for these purposes.

ALALITE. (See DIOPSIDE.)

ALANINE. $C^3H^7NO^2$. (**A. Strecker**, Ann. Ch. Pharm. lxxv. 29; **Gm.** ix. 434; **Gerh.** i. 678.) An organic base obtained by heating aldehyde-ammonia with hydrocyanic acid in presence of excess of hydrochloric acid.

$$C^2H^3O.NH^4 + CNH + HCl + H^2O = C^3H^7NO^2 + NH^4Cl.$$

To prepare it, an aqueous solution of 2 pts. aldehyde-ammonia is mixed with aqueous hydrocyanic acid containing 1 pt. of the anhydrous acid, hydrochloric acid is added in excess, and the mixture is boiled and afterwards evaporated to dryness over the water-bath. The residue consisting of hydrochlorate of alanine and a large quantity of sal-ammoniac, is digested in a little cold water, which leaves the greater part of the sal-ammoniac undissolved; the solution of hydrochlorate of alanine is boiled with hydrate of lead, added in small portions as long as ammonia continues to escape; the liquid is filtered; and the dissolved lead is precipitated from the solution by sulphuretted hydrogen. The filtered liquid yields crystals of alanine by evaporation, and an additional quantity may be obtained from the mother-liquor by addition of alcohol. Another and better method is to treat the mixture of hydrochlorate of alanine and sal-ammoniac with alcohol and ether, in which the former only is readily soluble, concentrate the solution by evaporation, and remove the hydrochloric acid by boiling with hydrate of lead.

Properties. — Alanine crystallises on cooling from a hot saturated solution in colourless needles having the form of oblique rhombic prisms united in tufts. They have a pearly lustre, are hard, and grate between the teeth. At 200°, it sublimes and falls down again in fine snowy crystals; when rapidly heated, it melts and suffers partial decomposition. It dissolves in 4·6 pts. of water at 17°, and in a smaller quantity of hot water; it is very sparingly soluble in cold alcohol, and quite insoluble in ether. The aqueous solution has a sweet taste, does not affect vegetable colours, and forms no precipitates with any of the ordinary reagents.

Alanine is isomeric with urethane, lactamide, and sarcosine; from the two former it is distinguished by not melting below 100°; from the last by being soluble in water, and by its behaviour with metallic oxides.

Decompositions. — Alanine is not altered by boiling with dilute acids, or with alkalis. It dissolves in strong sulphuric acid, and the solution does not blacken on boiling. Fused with hydrate of potassium, it gives off hydrogen and ammonia, and yields cyanide and acetate of potassium. When its aqueous solution is boiled with peroxide of lead, it is resolved into aldehyde, carbonic anhydride, and ammonia:

$$C^3H^7NO^2 + O = C^2H^4O + CO^2 + NH^3.$$

The aqueous solution is also decomposed by nitrous acid, with evolution of nitrogen and formation of lactic acid:

$$\underbrace{C^3H^7NO^2}_{\text{Alanine.}} + \underbrace{NO^2H}_{\text{Nitrous acid.}} = \underbrace{C^3H^6O^3}_{\text{Lactic acid.}} + 2N + H^2O.$$

Compounds of Alanine.—Alanine acts both as a base and as an acid. It unites directly with acids, and when boiled with metallic oxides forms compounds consisting of alanine with 1 atom of hydrogen replaced by a metal. With *hydrochloric acid*, it forms two compounds, viz. $2C^3H^7NO^2.HCl$, obtained by treating alanine with dry hydrochloric acid gas, and $C^3H^7NO^2.HCl$, produced by evaporating a solution of alanine in excess of hydrochloric acid. Both these compounds dissolve readily in water, sparingly in alcohol; the latter is very deliquescent, but may with some difficulty be obtained in crystals. On mixing a solution of alanine in hydrochloric acid with excess of bichloride of platinum, and evaporating, the chloroplatinate, $2C^3H^7NO^2.HCl.PtCl^2$, crystallises in slender yellow needles, soluble in water and alcohol, and even in a mixture of alcohol and ether. *Nitrate of alanine*, $C^3H^7NO^2,HNO^3$ is obtained by evaporating a solution of alanine in dilute nitric acid, in long colourless needles, which deliquesce in damp air, and dissolve very readily in water, less in alcohol; at 100°, they turn yellow and decompose. *Sulphate of alanine* is very soluble in water, and remains as a syrupy mass when its solution is evaporated; it may be washed with cold alcohol. It is not precipitated from its aqueous solution by alcohol, but a mixture of ether and alcohol separates it in the form of a thick syrup.

The *copper-compound* of alanine, $C^6H^{12}Cu''N^2O^4 + H^2O$, crystallises from a solution of alanine which has been boiled with cupric oxide, in dark blue needles and thicker rhombic prisms. It forms a dark blue solution in water, but is nearly insoluble in alcohol. The crystals remain unaltered at 100°, but at 120° they give off water, and are reduced to $C^6H^{12}Cu''N^2O^4$, assuming at first a lighter blue colour, and afterwards crumbling to a bluish-white powder. *The silver-compound*, $C^3H^6AgNO^2$, is obtained in a similar manner, and separates as the liquid cools, in small yellow needles united in hemispherical groups. They assume a darker colour when exposed to light, and also when heated to 100° in the moist state; but when dry they sustain that temperature without alteration. A solution of nitrate of silver mixed with alanine, yields by spontaneous evaporation colourless rhombic tables, which are decomposed by heat, with slight detonation, and leave a residue of spongy silver. A *lead-compound*, $C^6H^{12}Pb''N^2O^4.Pb''H^2O^2$, is obtained in colourless glassy needles, by boiling protoxide of lead in aqueous alanine, and evaporating and cooling the solution. It is also precipitated in radiating crystals, on mixing the aqueous solution with alcohol. The crystals dried over sulphuric acid give off water and crumble to a powder which is no longer completely soluble in water

ALANTIN. (See INULIN.)

ALBAN. A white, crystalline, resinous substance extracted from gutta percha by alcohol or ether. It is best obtained by treating gutta percha with ether, and digesting the resulting extract with alcohol, which dissolves a yellow resin, and leaves a white substance to which Payen gives the name of alban. After recrystallisation from absolute alcohol, it forms a white pulverulent mass, which begins to melt at 100°, is perfectly fluid and transparent between 175° and 180°, and contracts strongly in cooling. It dissolves with facility in oil of turpentine, benzol, sulphide of carbon, ether, hot alcohol, and chloroform, and separates from the solutions in the crystalline form. The crystals are wetted by watery liquids. They exhibit with sulphuric acid the same reactions as native gutta percha. (Payen, Compt. rend. xxxv. 109.)

ALBENE. A name given by Völckel to a white substance which, according to his observations, remains undissolved when melam is boiled with water. Völckel assigns to this substance the composition $C^{12} H^9N^{10}O^8$ (Ann. Ch. Phys. [2] lxii. 90).

ALBIN. (See APOPHYLLITE.)

ALBITE. Soda-felspar. (See FELSPAR.)

ALBUM GRÆCUM. An obsolete name for the excrements of the dog, formerly used as a remedy in medical practice. The substance contains about 79 per cent. of phosphate of calcium.

ALBUMIN. (Gerh. iv. 433; Lehmann, Physiological Chemistry i. 330; also Zoochemie in Gmelin's Handbuch, Bd. viii. Pelouze et Frémy, Traité de Chimie générale, vi. 67.) Albumin is the chief and characteristic constituent of white of egg and of the serum of blood, and occurs in all those animal substances which supply the body or individual parts of it with the materials required for nutrition and renovation. It forms about 7 p. c. of blood and 12 p. c. of white of egg; it is a principal constituent of chyle, lymph and of all serous fluids. It occurs also in the juice of flesh, in the brain, the pancreas, the amniotic liquid, and generally in a greater or smaller quantity in all the liquids (transudates) effused from the blood-vessels into the cellular tissues of the organs, into the cavities of the body, or on to the surface. It is found in the solid excrements of man and of other animals, the quantity increasing in disorders of the mucous membrane of the intestinal canal. It is not found in normal urine, but is present in that liquid in many states of disease, especially in affections of the respiratory organs, which interfere with the process of oxidation.

Albumin exists in two very distinct modifications, viz. the *soluble* form, in which it always occurs in the animal body, and the *insoluble* form, into which it may be brought by the action of heat, as when white of egg or blood-serum is boiled. These two modifications of albumin are identical in chemical composition, the difference between them being due, partly, perhaps, to peculiarity of molecular aggregation, but chiefly to the presence of certain mineral salts which are always associated with the soluble variety. In fact, albumin does not occur in the animal body in the free state, but in the form of an alkaline albuminate; white of egg, serum, and all liquids which contain albumin, leave, when incinerated, an ash chiefly consisting of alkaline carbonate. Insoluble albumin does not appear to exist in the living animal organism, unless indeed, fibrin may be regarded as coagulated albumin, which is by no means improbable, inasmuch as there is no exact method of distinguishing between the two.

Preparation. — Albumin may be prepared either from white of egg, or from blood-serum. White of egg consists of transparent thin-walled cellules, enclosing an alkaline solution of albuminate of sodium. On beating it up with water, the cellular substance separates in pellicles, while the albuminate of sodium remains in solution, together with chloride of sodium and phosphate of calcium. To remove these mineral substances, the liquid, after being filtered from the cellular substance, is mixed with a small quantity of subacetate of lead, which produces an abundant precipitate (an excess of the lead-salt would redissolve it). The mass, after being washed, is stirred up with water to the consistence of a paste, and carbonic acid gas is passed through the liquid. The albuminate of lead is thereby decomposed, carbonate of lead remains suspended in the liquid, and the albumin in the free state remains dissolved. The solution is filtered through paper previously washed with dilute acid, and, as it still retains traces of lead, it is treated with a few drops of aqueous hydrosulphuric acid, and cautiously heated to 60°, till it begins to show turbidity; the first flocks of albumin thus precipitated carry down the whole of the sulphide of lead. When the liquid which after filtration is perfectly colourless, is evaporated in large capsules at 40°, a residue is obtained consisting of pure *soluble* albumin (Wurtz, Ann. Ch. Phys. [3] xii. 27). The same method applied to the albumin of blood-serum does not yield a pure product.

To obtain pure albumin in the coagulated state, white of egg, diluted with an equal bulk of water, filtered, and reduced to its original volume by evaporation at 40°, is mixed with a strong solution of potash, whereby it is soon converted into a translucent, yellowish elastic mass. This is divided into small portions and exhausted with cold water as long as the water removes any alkali, the whole being kept as much as possible from contact with the air. It is then dissolved in water or boiling alcohol, and the solution is precipitated by acetic or phosphoric acid. The precipitate, after washing, leaves no appreciable residue when incinerated. (Lieberkühn.)

Properties. — Soluble albumin, dried in the air, forms a pale yellowish, translucent mass, easily triturated and reduced to a white powder. The specific gravity of the albumin of the hen's egg, from which the salts had not been removed, was found by C. Schmidt (Ann. Ch. Pharm. xi. 156–167), to be 1·3144, and after calculating for the elimination of the salts, the density of pure albumin was found to be 1·2617. It becomes electric by friction, and is tasteless, inodorous and neutral to vegetable colours. It swells in water, assuming a gelatinous appearance; it does not dissolve freely in pure water, but very readily in water containing any alkaline salt. After being dried in vacuo, or at a temperature below 50°, it may be heated to 100° without passing into the insoluble modification. Soluble albumin dried at 60° loses 4 p. c. water at 140°, remaining, however, soluble in water.

The aqueous solution of albumin deviates the plane polarisation of a ray of light to the left. It becomes opaline at 60°, begins to deposit the albumen at 61° to 63°, and at a temperature a little higher the whole coagulates in a mass. When very dilute, it becomes turbid without coagulating; but if the liquid be then concentrated by evaporation, it deposits the albumin in pellicles or flocks.

Coagulated albumin is white, opaque, elastic, and reddens litmus (Hruschauer, Ann. Ch. Pharm. xlvi. 348). When dried, it assumes a yellow colour, and becomes brittle and translucent like horn. When immersed in water, after drying, it gradually absorbs about five times its weight of the liquid, and resumes its primitive consistence.

When coagulated albumin is boiled in *water* for about 60 hours, it gradually disappears, being transformed into a substance soluble in water, and consisting, according to Mulder and Baumhauer (J. pr. Chem. xx. 346; xxxi. 295), of *trioxide of protein*, $C^{40}H^{31}N^{5}O^{15}$ (C = 50·98 p. c.; H = 6·69; O and S = 5·01; N = 27·32). Coagulated albumin, heated to 150° with a small quantity of water in a sealed tube, gradually forms a limpid solution, which has no longer the property of coagulating by heat. (L. Gmelin.)

Albumin is insoluble in *alcohol* and in *ether*. Strong alcohol added in large excess, precipitates albumin from its aqueous solution in the same state as when it is coagulated by heat; but the precipitate produced by a small quantity of weak alcohol redissolves completely in water. When alcohol is added to a somewhat dilute solution of albumin, so as to render it slightly opaline, the liquid after a while, solidifies in a jelly, which, however, is again liquefied by heat. Coagulated serum, or white of egg, may be made to dissolve in alcohol by the addition of a little alkali. (Scherer.)

Ether shaken up with a solution of albumin coagulates but a small portion of it; if, however, the albuminous solution is concentrated, it thickens so much as to appear coagulated. Albumin is not acted upon by oils either fixed or volatile.

Nearly all *acids* precipitate albumin from its solutions. *Nitric acid* precipitates it with peculiar facility, and may therefore be used as a test of the presence of soluble albumin. Strong *hydrochloric acid* aided by heat dissolves coagulated albumin, forming a blue or violet solution, which turns brown when boiled in an open vessel, and according to Bopp (Ann. Ch. Pharm. lxix. 30) yields chloride of ammonium, leucine, tyrosine, and other products of unknown composition. With *aqua regia*, albumin yields both chlorinated and nitro-compounds.

Strong *sulphuric acid* coagulates albumin by the heat which is evolved when the two liquids come in contact. Dilute sulphuric acid precipitates albumin after some time only, not however combining with it, as the acid may be completely removed from the precipitate by washing.

Tribasic phosphoric acid, *acetic*, *tartaric*, and most other organic acids do not form precipitates in moderately concentrated solutions, of albumin; but when either of these acids is added in excess to a highly concentrated solution of serum or white of egg, the liquid solidifies in the cold to a jelly which liquefies like gelatin when heated, and again forms a gelatinous mass on cooling. The aqueous solution of this jelly remains perfectly transparent when boiled, but it is precipitated by a neutral salt of either of the alkali-metals. (Lieberkühn.)

When a small quantity of acetic acid is added to white of egg or serum, so as just to saturate the alkali, and the liquid is then largely diluted with water, flocks of albumin are deposited after awhile. If the supernatant liquid be then decanted, and the precipitate treated with a small quantity of solution of nitre or common salt, it immediately dissolves, and the solution is coagulated by boiling. (Scherer.)

Serum or white of egg mixed with a certain quantity of *common salt* or other salt of an alkali-metal, forms a liquid precipitable by phosphoric, acetic, tartaric, oxalic, lactic acid, &c. Conversely, a solution of albumin (or other albuminoïdal substance) in acetic acid is precipitated by the salts of the alkali-metals. The precipitation is greatly facilitated by heat, and likewise takes place with greater facility as the proportion of salt added is greater. The precipitate dissolves in pure water, with greater facility in proportion as less heat has been applied in producing it; the solution is not coagulated by heat. It is soluble also in acetic acid, phosphoric acid, and even in alcohol, provided it has not been altered by desiccation, or by contact with the air. The aqueous solution is precipitated by certain salts, ferrocyanide of potassium, for example.

Dried soluble albumin suspended in acetic, tartaric, or citric acid, swells up and is converted into coagulated albumin, which may be completely freed from acid by washing. Acetic, tartaric, and tribasic phosphoric acid dissolve coagulated albumin when heated with it. Arsenious acid does not combine with albumin. Chlorine and bromine precipitate albumin.

Alkalis do not in general precipitate albumin from its solutions; but a strong solution of potash added in considerable quantity to a solution of albumin, forms a gelatinous mass of albuminate of potassium. Dilute solutions of potash and soda mix with albumin in all proportions, and on boiling the liquid, an alkaline sulphide is formed. When albumin is heated with hydrate of potassium melted in its water of crystallisation, the water being renewed as it evaporates, ammonia and hydrogen are evolved, leucine and tyrosine are produced, together with oxalate, butyrate valerate, &c. of potassium. *Alkaline carbonates* added to a solution of albumin prevent its coagulation by heat. Coagulated albumin digested at a gentle heat with neutral carbonate or acid carbonate of sodium, displaces the carbonic acid, and forms with the alkali a compound, which, after washing, is perfectly neutral to test paper, but leaves when incinerated a considerable quantity of alkaline carbonate.

Albumin subjected to *dry distillation* yields water, carbonate of ammonium, hydrosulphate of ammonium, volatile alkalis of undetermined composition, empyreumatic oils, &c. Coagulated albumin putrifies when left in contact with water, yielding valeric and butyric acids, a crystalline body having a penetrating odour, an oily acid, and a substance which dissolves in hydrochloric acid, producing a liquid of beautiful violet colour and yielding tyrosine, together with other products (Bopp, Ann. Ch. Pharm. lxix. 30). The *oxygen* of the air has no action on serum or white of egg. Recently extracted serum left for a fortnight in contact with oxygen in a tube standing over mercury absorbs but a very small quantity of the gas, and does not form carbonic acid.

Albumin distilled with a mixture of *peroxide of manganese and sulphuric acid* yields acetic, propionic, butyric, and benzoic aldehydes, together with formic, acetic, butyric, valeric, and benzoic acids, and probably also propionic and caproic acids. Nearly the same products are obtained by distilling albumin with *sulphuric acid and acid chromate of potassium*, this mixture yielding in fact, hydrocyanic acid, a heavy oil having the odour of cinnamon, cyanide of tetryl (valeronitrile), also benzoic, acetic and butyric acids, with small quantities of formic, caproic and propionic acids, and of benzoic and propionic aldehydes (Guckelberger, Ann. Ch. Pharm. lxiv. 39). Albumin does not decompose *oxygenated water*.

Composition of Albumin. — Albumin obtained from various animal fluids exhibits the same composition, as shown by the following analyses: —

	From White of Egg.					
	Mulder.	Scherer.	Dumas and Cahours.	Rülling.	Wurtz.	Lieberkühn.
Carbon	53·4	54·3	53·4	53·4	52·9	53·3
Hydrogen	7·0	7·1	7·1	7·0	7·2	7·1
Nitrogen	15·7	15·9	15·8	..	15·6	15·7
Oxygen	..	..	..	..	..	22·1
Sulphur	..	..	..	1·7 to 1·8	..	1·8

Wurtz's analysis was made with soluble, the rest with coagulated albumin. Mulder supposes that albumin contains also 0·4 per cent. phosphorus. Most of the preparations with which the above analyses were made, contained small quantities of phosphorus in the form of phosphate of calcium.

	From Blood-serum.				
	Dumas and Cahours.		Mulder.	Rülling.	Scherer.
Carbon	53·3	53·5	53·4	53·1	54·5
Hydrogen	7·1	7·3	7·1	7·0	7·0
Nitrogen	15·7	15·8	15·6	..	15·7
Oxygen	..	..	..	..	..
Sulphur	..	..	1·3	1·3	..

Mulder supposes that blood-albumin contains also 0·3 per cent. phosphorus. Rüling found the amount of sulphur in eight analyses to vary from 1·29 to 1·39 per cent.

	Scherer.			Weidenbusch.	Baumhauer.
	a	*b*	*c*	*d*	*e*
Carbon	54·2	54·1	54·0	53·3	54·3
Hydrogen	7·1	7·2	7·0	7·0	7·1
Nitrogen	15·5	15·8	15·8	15·7	15·8
Oxygen	..	..	..	..	..
Sulphur	..	..	..	..	..

a from a hydrocele; *b* from a congestion-abscess; *c* from pus; *d* from flesh of poultry; *e* from the flesh of fish.

From these and other analyses, Liebig deduces the formula $C^{216}H^{338}N^{54}S^{3}O^{68}$: Mulder, $C^{90}H^{139}N^{22}SO^{28}$: Lieberkühn, $C^{72}H^{112}N^{18}SO^{22}$. Each of these formulæ gives numbers agreeing nearly with the analytical results. Mulder regards albumin as a compound of (hypothetical) protein with (hypothetical) sulphamide, viz.:

$$C^{90}H^{139}N^{22}SO^{30} = \underbrace{5C^{18}H^{27}N^4O^6}_{\text{Protein.}} + \underbrace{N^2H^4S}_{\text{Sulphamide.}}$$

Liebig's formula is intended merely to express in a simple form certain relations between albumin and other animal substances. Lieberkühn, on the other hand, regards his formula as actually expressing the composition of the molecule of albumin as it exists in the metallic albuminates (*q. v.*)

According to **Lebonte** and **Goumoens** (J. Pharm. [3] xxiv. 17) albumin is not a pure proximate element, but a mixture of two bodies, one of which is insoluble in glacial acetic acid, while the other dissolves in that acid and is precipitated therefrom by potash.

The properties of albumin vary in some degree with the source from which it is derived. The differences may in some cases be attributed to the presence of different mineral substances; but in others they are of such a nature as rather to point to the existence of different modifications of albumin. Thus, **Frémy** and **Valenciennes** have found (Ann. Ch. Phys. [3] l. 138) that the albumin of the eggs of certain tribes of birds exhibits peculiar modifications. That from the eggs of different species of gallinaceous birds always exhibits the characters above described; but the eggs of swimming and wading birds yield an albumin which, when diluted with 3 measures of water, is not coagulated by heat, but is precipitated by nitric acid; and the albumin from the eggs of predaceous birds, and of some kinds of perching and climbing birds is neither coagulated by heat nor precipitated by nitric acid. The composition was, however, found to be the same in all cases.

Blood-albumin exhibits the same reactions as that from white of egg, excepting that the latter when boiled gives up part of its sulphur in the form of sulphuretted hydrogen, which blood-albumin does not; nevertheless coagulated white of egg appears to contain more sulphur than blood-albumin.

Paralbumin. — Scherer found in a liquid obtained from a case of ovarian dropsy, a substance resembling albumin, but differing from it in not being completely precipitated by ebullition, even after addition of acetic acid, and in dissolving in water after being precipitated by alcohol. *Metalbumin* is the name given by the same chemist to another supposed modification of albumin, likewise obtained from a pathological fluid, which exhibited similar peculiarities to the preceding, and was further distinguished by giving no precipitate with hydrochloric acid, or with ferrocyanide of potassium after acidulation with acetic acid.

Other substances more or less resembling albumin are: *globulin* or *crystallin* existing in blood-globules and in the crystalline lens of the eye; *hæmatocrystallin*, a crystalline body obtained from blood, and *vitellin*, existing in the yolk of eggs (see these substances).

Quantitative Estimation of Albumin. — The best mode of precipitating albumin from alkaline liquids (serum, for example), for quantitative estimation, is to neutralise or slightly acidulate the liquid with acetic acid, and then coagulate the albumin by boiling. The precipitate thus obtained is flocculent and may be easily collected on a filter and washed, the liquid passing through perfectly clear, whereas if the albumin be coagulated by heat alone, it is very apt to clog the filter. Another reason for using the acetic acid is, that mere boiling does not precipitate the albumin completely from alkaline solutions. The precipitated albumin, after being thoroughly washed, may be dried in vacuo over sulphuric acid or in a current of warm air.

Uses of Albumin.— Albumin is much used for clarifying vinous and syrupy liquids, inasmuch as, when boiled with them, it coagulates, and takes hold of the colouring matter and other impurities, thereby removing them, and carrying them to the bottom or to the surface of the liquid, according to its density. In cookery, white of egg is employed for this purpose, but in large operations, such as sugar-refining, the serum of blood is used. Albumin is applied to a considerable extent for fixing colours in calico-printing; it is also used in photography. Its property of forming a hard compound with lime renders it very useful for making cement for laboratory purposes and for mending broken earthenware. A paste made of white of egg and slaked lime, acquires after a while the hardness of stone.

ALBUMINATES. (**Lassaigne**, Ann. Ch. Phys. [3] lxiv. 90; **Lieberkühn**, J. Pharm. [3] xxxiii. 398; **Lehmann**, Physiol. Chem. i. 332; **Gerh.** iv. 447.) — Albumin is a weak acid, and apparently dibasic. Its compounds with the alkalis are soluble and are obtained directly by treating albumin with caustic alkalis or alkaline carbonates. The other albuminates are insoluble and are obtained by precipitation.

Albuminate of Barium, $C^{144}H^{222}Ba''N^{36}S^2O^{44} + 2H^2O$ (?)—A solution of albuminate of potassium in dilute alcohol forms with barium-salts, a precipitate which dries up to a white powder, insoluble in water, alcohol and ether. White of egg mixed with caustic baryta, strontia or lime, forms an insoluble compound, which becomes very hard when dry.

Albuminate of Copper, $C^{72}H^{110}Cu''N^{18}SO^{22} + H^2O$ (?) — Obtained in like manner forms when dry, a green, brittle mass, insoluble in water and alcohol. Acids decolorise, but do not dissolve it (Lieberkühn). According to Lassaigne, double albuminates of copper with potassium, or barium, or calcium, may be obtained by heating hydrate of copper with solution of albumin and solution of potash, baryta or lime. There is also an albuminate of copper and magnesium which is insoluble and has a lilac colour.

Albuminate of Lead is a white insoluble salt, obtained by mixing the solution of albumin and subacetate of lead; it is soluble in excess of the lead-salt, and is decomposed by all acids.

Mercuric Albuminate is a white substance obtained by precipitating corrosive sublimate with albuminate of sodium (white of egg). It is insoluble in pure water, but soluble in saline liquids; for this reason, when white of egg is used as an antidote in cases of poisoning by corrosive sublimate, endeavours should always be made to produce vomiting; otherwise a portion of the mercuric albuminate may remain dissolved in the gastric juice, which contains chloride of sodium.

Albuminate of Potassium, $C^{72}H^{110}K^2N^{18}SO^{22} + H^2O$. — Prepared by mixing a concentrated solution of white of egg with strong potash-ley, and washing the resulting gelatinous mass with cold water, as long as any alkali dissolves out, then dissolving the residue in boiling alcohol, and precipitating by ether. After drying, it is no longer soluble in boiling alcohol or in water. The aqueous solution is not coagulated by boiling or by addition of alcohol. With a small quantity of acetic, tartaric, citric or phosphoric acid, it yields an abundant white precipitate easily soluble in excess of acid. These characters are the same as those of casein; hence, Gerhardt considers it probable that casein may be really albuminate of potassium.

Albuminate of Sodium is contained in blood-serum and in white of egg, together with chloride of sodium and phosphate of calcium. Serum and white of egg have a slight alkaline reaction, are more soluble in water than pure albumin, and when boiled, coagulate in a gelatinous mass, not in flakes. After boiling, the filtered liquid is more alkaline than before, and still contains albuminate of sodium, whereas the coagulum is free from alkali. Hence, Gerhardt thinks it probable that serum and white of egg contain an acid albuminate of sodium, $C^{72}H^{111}NaN^{18}SO^{22}$, which is decomposed by heat into the neutral albuminate, and free albumin which separates from the liquid. This view is, moreover, in accordance with the composition of dried white of egg, which, according to Lehmann's analysis, contains 1·6 per cent. of soda, the formula $C^{72}H^{111}NaN^{18}SO^{22} + H^2O$ requiring 1·8 per cent. White of egg or serum treated with strong caustic soda, yields a gelatinous mass nearly insoluble in cold water, and closely resembling the compound produced under the same circumstances by potash. This gelatinous salt appears to be the neutral *albuminate of sodium*, $C^{72}H^{110}Na^2N^{18}SO^{22} + H^2O$. It contains, according to Lehmann, 3·14 per cent. soda (by calculation 3·7).

Albuminate of Silver, $C^{72}H^{110}Ag^2N^{18}SO^{22} + H^2O$ (?) — Obtained by precipitation. White, flocculent, blackens when exposed to light.

Albuminate of Zinc, $C^{72}H^{110}Zn''N^{18}SO^{22} + H^2O$ (?)—White powder insoluble in water, alcohol, and ether.

ALBUMIN, VEGETABLE. (Gerh. iv. 444; Handw. d. Chem 2te Aufl. ii. 147.) — Most vegetable juices contain a substance which appears to be identical in composition and properties with the albumin of blood or of white of egg. The same compound appears also to exist in the solid form in certain parts of plants, especially in the seed. Vegetable juices containing albumin deposit it, when heated to 65° or 70°, in flocks, which are often coloured greenish by chlorophyll, and contain fatty and waxy substances mechanically enclosed. To remove these matters, the coagulum must be washed, first with water, then with boiling alcohol and with ether.

Albumin is especially abundant in the juice of carrots, turnips, cabbages, and the green stems of peas, but it is more easily prepared from potatoes, by cutting them into slices, covering them with very dilute sulphuric acid (of 2 p.c.), leaving the liquid to itself for 24 hours, then adding fresh potatoes, and repeating the same operation once more, afterwards neutralising the solution with potash, and boiling. A considerable quantity of albumin is then deposited in thick white flocks.

Wheat-flour also contains a considerable quantity of albumin, which may be extracted with cold water. For this purpose, the water which runs off in washing the paste of wheat-flour for the preparation of gluten (*q. v.*) is left at rest till the starch is completely deposited; the clear liquid is then heated to the boiling point, whereupon it deposits a small quantity of albumin; on evaporating the solution a larger quantity is obtained.

Oleaginous seeds likewise contain albumin, which may be extracted by beating the seeds with water into an emulsion, extracting the fat by agitation with ether, and the albumin by boiling.

When sweet almonds which have been freed from their envelopes are reduced to a pulp by rasping, and the pulp is digested for a few minutes in boiling water, the sugar, gum, and the greater part of the legumin contained in the almonds enter into solution; and on depriving the residue of fatty matter by means of ether, nothing is left but coagulated albumin, exhibiting the same characters as coagulated white of egg.

	a	*b*	*c*		*d*	*e*	*f*	*g*
Carbon	54·0	53·7	51·9	to 52·0	53·1	52·0		
Hydrogen	7·8	7·1	6·9	7·0	7·2	6·8		
Nitrogen	15·8	15·7	18·4	..	..	..		
Oxygen	..	..	..	..	..	..		
Sulphur	..	..	..	..	0·97	0·79	1·0	0·77

a, albumin from rye, analysed by Jones (Ann. Ch. Pharm. xl. 66); *b*, from wheat-flour, by Dumas and Cahours (Ann. Ch. Phys. [3] vi. 309); *c*, from wheat-flour by Boussingault (ibid. [2] lxiii. 225); *d*, from potatoes by Rüling (Ann. Ch. Pharm. lviii. 306); *e*, from peas by Rüling; *f*, *g*, from rye, by Mulder.

Vegetable albumin is distinguished from legumin (vegetable casein) by being coagulated by heat, and not precipitated by acetic acid. It exhibits the same reactions as animal albumin with acids, alkalis, tannin, chloride of mercury, &c. The mode of its occurrence differs, however, remarkably from that of animal albumin in this respect, that it is always found in plants in neutral or acid liquids, whereas animal albumin exists only in alkaline liquids (p. 25).

The albumin of sweet almonds is remarkable for the facility with which it decomposes, and by its property of acting as a ferment, and determining the metamorphosis of amygdalin, salicin, and other organic bodies. This altered albumin is distinguished by the terms *emulsion* and *synaptase* (*q. v.*)

The *myrosin* of mustard-seeds likewise resembles vegetable albumin. Lastly, the *diastase* of germinated barley, *beer-yeast*, and *wine-lees* are likewise albuminoïdal substances in a state of alteration.

ALBUMININ, *Oonin.* (Handw. d. Chem. 2te Aufl. i. 404.)—The name given by Couerbe to the substance of the cells which enclose the white of birds' eggs. It is obtained by exposing white of egg for a month to temperature between 0° and—8°, in the form of a white filmy substance, which when dried is white, translucent in thin laminæ and easily friable. It does not contain nitrogen, and consequently does not evolve ammonia when heated. It is insoluble in water, whether hot or cold, but swells up in hot water, forming a gummy mass. It is not acted upon by alcohol, ether, or acetic acid. Nitric and sulphuric acids decompose it. It dissolves in hydrochloric acid, and on adding water to the solution, a white powder is precipitated. It dissolves in caustic potash, forming a solution which is rendered turbid by acids, but not precipitated.

ALBUMINOÏDS. *Protein-compounds. Blutbilder.* (Gerh. iv. 430; Handw. d. Chem. 2te Aufl. ii. 120.)—This term is applied to a class of compounds which play an important part in the functions of animal and vegetable life. Three of them, *albumin*, *casein*, and *fibrin* are distinguished by well-marked characters.

Fibrin separates spontaneously in the solid form from blood, soon after its removal from the living body; albumin is contained in the serum or more liquid portion of the blood, and separates from it as a coagulum on the application of heat; and casein is contained in milk, from which it may be separated, not by heat, but by the addition of an acid. The same substances are found in plants, viz. fibrin, in the grain of wheat and other cereal plants; albumin in most vegetable juices, and casein (or legumin) in the seeds of the pea, bean and other leguminous plants.

The other bodies of this class are less distinctly characterised; indeed, most of them appear to be mere modifications of the one or other three above-mentioned; thus, *syntonin*, the essential constituent of the muscular fibre, closely resembles blood-fibrin; *vitellin*, a substance occurring in the yolk of eggs, is scarcely distinguishable from albumin; and *globulin* and *hæmatocrystallin*, two substances contained in the blood, resemble albumin in the property of coagulating by heat.

Moreover, albumin, fibrin, and casein, though clearly distinguished from one another by the different conditions under which they pass from the liquid to the solid state, nevertheless possess many characters in common. They all dissolve in caustic potash or soda, and when boiled with those alkalis, yield solutions from which acids precipitate them in a more or less altered state, and at the same time eliminate hydrosulphuric acid. When subjected to dry distillation, they all give off ammonia (or compound ammonias). They all decompose and putrefy with great facility when exposed to moist air, and in that form are very active as *ferments;* thus, yeast, wine-less, diastase, &c., are merely albuminoïdal substances in a peculiar state of decomposition.

All albuminoïds treated with oxidising agents, such as mixtures of peroxide of manganese or acid chromate of potassium and sulphuric acid, yield the same products, viz. acids and aldehydes of the acetic and benzoic series (see ALBUMIN, p. 67).—Albuminoïds dissolve in very strong hydrochloric acid, forming a solution which is yellow if kept from contact with the air, but assumes a fine blue or violet colour on exposure to the air.—A solution of mercury in an equal weight of nitric acid imparts to these bodies a very deep red colour, this test serving to detect the presence of 1 part of albumin in 100,000 parts of water.

All the albuminoïds exhibit the same or nearly the same constitution. In the living organism, albumin, fibrin, and casein are constantly being converted one into the other. The casein of milk supplies the material for the formation of albumin and fibrin; and conversely, albumin and fibrin are converted into casein. Indeed, the analyses of different bodies of the class do not differ from one another more than analyses of the same body from different sources or by different experimenters. They contain 50 to 54 p. c. carbon, about 7 p. c. hydrogen, 15 to 17 p. c. nitrogen, about 25 p. c. oxygen, and from 0·9 to 1·8 sulphur. According to some analyses, however, fibrin contains rather less carbon and more nitrogen than albumin. Albumin and fibrin have been supposed by some chemists to contain also a small quantity of phosphorus as an organic constituent, but its existence is not well established. Most albuminoids are associated with small quantities of mineral substances, including phosphate of calcium, which cannot be separated from the organic matter by acids.

This great similarity of composition and properties exhibited by these bodies has led to various views of the relation between them. Mulder supposed that all the albuminoïds contain the same organic group, $C^{18}H^{27}N^4O^6$, which he called *protein*, combined with different quantities of sulphur and phosphorus, and that the conversion of one of these bodies into the other depends upon the assumption or elimination of small quantities of one or both of those elements (see PROTEIN). Mulder also stated, that when an albuminoïd is treated with caustic alkali, the sulphur and phosphorus are removed and the protein remains. The researches of other chemists have shown, however, that this view is untenable. Neither of the albuminoïds contains phosphorus, and the proportion of sulphur appears to be the same in them all: at all events, fibrin and egg-albumin, which perhaps exhibit the greatest difference of physical and chemical properties, do not differ perceptibly in amount of sulphur. Moreover, the sulphur of albuminoïds cannot be completely extracted by the action of alkalis, so that the existence of the so-called protein is merely hypothetical.

Gerhardt was of opinion that all the albuminoïds are identical, not only in composition, but in chemical constitution, and that they differ from one another only in molecular arrangement, and by the nature of the mineral substances with which they are associated; in fact, that they contain a common proximate element which, like many other organic compounds, is capable of existing in a soluble and in an insoluble modification. Designating this common element by the name albumin, he supposed that white of egg and serum consist of acid albuminate of sodium (p. 99), which is separated by heat into free albumin and neutral albuminate of sodium, the latter remaining dissolved; that casein, which is soluble and non-coagulated by heat, consists of neutral albuminate of potassium, from which the organic compound may be precipitated by neutralising the alkali with an acid; and that fibrin is albumin in the insoluble state, more or less mixed with earthy phosphates. This view is in accordance with the fact that fibrin and casein may be dissolved in neutral potassium-salts (better with addition of a little caustic alkali), forming a liquid which coagulates by heat, and deflects the plane of polarisation of a luminous ray to the left, like albumin; and that fibrin and albumin, dissolved in a certain quantity of caustic alkali, exhibit the characters of soluble casein. Nevertheless, it is possible to obtain the albuminoïds in some cases wholly, in others very nearly, free from mineral matters, and nevertheless exhibiting their distinguishing characteristics. Moreover, it is certain that all these bodies contain the same proportions of carbon, nitrogen, and sulphur.

Strecker (Handw. d. Chem. 2te Aufl. ii. 124) supposes the albuminoïds to be composed of a great number of radicles (a supposition in accordance with the variety of their products of decomposition); that the greater number of these radicles are the same in all—hence their great similarity,—but that each contains one or more such radicles peculiar to itself. Thus, when casein is converted in the animal body into albumin and fibrin, it may take the radicles required for that transformation from the other constituents of the milk, viz. the fat and the sugar. (See ALBUMIN, BLOOD, CASEIN, CRYSTALLINE, FIBRIN, GLOBULIN, HÆMATOCRYSTALLIN, LEGUMIN, MILK, VITELLIN.)

ALBUMINOSE. This term is applied by Bouchardat to a product of the decomposition of animal fibrin by very dilute hydrochloric acid (see FIBRIN), and by Mialhe, to a peculiar substance into which he supposes albumin to be converted by the action of the gastric juice before it is assimilated.

ALCARRAZAS. Very porous vessels of slightly burnt clay used in hot climates for cooling water and other liquids. The liquid oozes through the pores and stands on the outside of the vessel in a sort of dew, which rapidly evaporates, especially if the vessel is exposed to a current of air, and thereby cools the liquid.

ALCHEMILLA VULGARIS. 100 pts. of the fresh plant contain, according to Sprengel: 76·0 pts. water, 10·3 pts. extractable by water, and 7·8 by dilute potash-ley; 5·6 woody fibre and 1·66 ash free from carbonic acid. The ash contained in 100 pts.; 30·5 potash, 2·4 soda, 33·6 lime, 4·9 magnesia, 0·9 alumina, 14·4 silica, 4·4 sulphuric anhydride, 5·4 phosphoric anhydride, 3·5 chlorine, and traces of the oxides of iron and manganese.

ALCOHOL. $C^2H^6O = C^2H^5.H.O$ [or $C^4H^6O^2 = C^4H^5O.HO.$]. This compound, which is the spirituous or intoxicating principle of wine, beer, and other fermented liquors, may be regarded as the hydrate or hydrated oxide of ethyl, or as a molecule of water, $\dot{H}HO$, in which half the hydrogen is replaced by the radicle *ethyl*, C^2H^5. It has also been regarded as a compound of ethylene and water, $C^2H^4.H^2O$.

History.— Intoxicating drinks produced by fermentation of vegetable juices containing sugar, have been known from the earliest times; but it was not till the twelfth century that the method of obtaining pure spirit of wine or hydrated alcohol from these liquids by distillation, was discovered by Abucasis; and the dehydration of this liquid was first partially effected by means of carbonate of potassium by Raimond Lullius in the thirteenth century. The mode of obtaining perfectly anhydrous alcohol was afterwards discovered by Lowitz.

Formation.—1. By the decomposition of glucose (grape-sugar) under the influence of ferments, that is to say, of nitrogenous organic substances, such as yeast, which are themselves undergoing decomposition. The sugar is then resolved into alcohol and carbonic anhydride:

$$C^6H^{12}O^6 = 2C^2H^6O + 2CO^2.$$

Other kinds of sugar, cane-sugar for example, as well as starch, woody fibre and other vegetable substances, also yield alcohol under the influence of ferments, but they are first converted into glucose.

2. From ethylene or olefiant gas, by addition of the elements of water:

$$C^2H^4 + H^2O = C^2H^6O.$$

Olefiant gas briskly agitated for a long time with strong sulphuric acid, is absorbed, and on diluting the liquid with water and distilling, alcohol passes over. This mode of formation, first observed by Hennel (Phil. Trans. 1826, p. 240), has lately been confirmed and fully examined by Berthelot (Ann. Ch. Phys. [3] xliii. 385). As olefiant gas can be obtained from inorganic materials, it follows that alcohol may be produced without the agency of living organisms.

Preparation. 1. *Of Hydrated or Aqueous Alcohol.*—When wine and other liquids which have undergone the vinous fermentation are distilled, alcohol passes over together with a considerable quantity of water; and by subjecting the product to repeated distillations, spirit is obtained continually richer in alcohol, because the alcohol, being more volatile than the water, passes over in larger quantity than the latter. But it is not possible to remove the whole of the water by simple distillation. The residue of the distillation, if continued long enough, is nothing but water containing small quantities of acetic acid (produced by oxidation of the alcohol) and fusel oil. Portions of these impurities also pass into the rectified spirit. The greater part of the acetic acid however, and a considerable portion of the fusel oil are left in the residues of the several distillations. The last portion of the acid is easily removed by distillation over a small quantity of carbonate of potassium or wood-ashes: and the fusel oil, which adheres more obstinately, and imparts a very unpleasant odour to the spirit, is best removed by adding to the spirit about 0·7 of its weight of coarsely powdered charcoal, leaving the mixture to stand for several days, and stirring it repeatedly, then decanting and distilling. Bone-black or blood-charcoal may also be used.

2. *Of Anhydrous or Absolute Alcohol.*—Alcohol cannot be completely dehydrated by distillation, because, at the boiling-point of pure alcohol (78° C.), the vapour of water possesses a considerable tension. The most highly rectified spirit obtained by frac-

tional distillation, still retains about 9 per cent. of water. The last portions of water must be removed by the agency of some substance which has a powerful attraction for it. Carbonate of potassium, chloride of calcium, and quick lime, are the substances most commonly used for this purpose, more rarely acetate of potassium, sulphate of copper, and other salts.

a. By *Carbonate of Potassium.*—Highly rectified spirit is shaken up with ignited carbonate of potassium, which forms a watery or pasty layer at the bottom. The alcohol, whose density is thereby lowered to 0·815, is poured off into a distilling vessel containing twice the quantity of pulverised and recently ignited carbonate of potassium, left to stand for 24 hours, and then two-thirds of it are distilled off (Lowitz). This method does not however remove the last minute portions of water.—*b.* A more complete dehydration is effected by *chloride of calcium.* The salt fused or dehydrated by a heat of 400° C. is added in thick lumps to twice its weight of spirit containing 90 per cent. of real alcohol; and the mixture left for some days in a closed vessel and occasionally shaken up, after which it is distilled in a retort over a fresh quantity of fused chloride of calcium. The retort is heated in a sand or oil bath with its neck directed upwards to prevent the contents from spirting over. When the quantity of water is large, a second treatment with chloride of calcium is necessary to effect complete dehydration.

c. By *Quick lime.*—A retort is two-thirds filled with small pieces of quick lime, and a quantity of 90 per cent. spirit poured in sufficient to nearly cover the lime. The lime soon slakes and becomes heated; the mixture is left to digest for some hours; and the anhydrous alcohol is then distilled off in the water-bath. The distillation must be carefully conducted, otherwise the distillate will be contaminated with lime. Alcohol containing fusel oil acquires a very unpleasant odour when treated with lime. This is by far the easiest method of obtaining absolute alcohol.

d. When aqueous alcohol is enclosed in a bladder, and exposed to warm air, the water gradually percolates through the bladder and evaporates, and absolute alcohol is left inside. (Sömmering.)

Alcohol may be regarded as anhydrous if sulphate of copper previously burnt white does not acquire any blue colour when immersed in the alcohol in a close vessel (Cassoria), or if it forms a perfectly clear mixture with benzol (Görgeu). It is doubtful however whether either of these tests will indicate the presence of a very minute quantity of water.

Properties.—Alcohol is a transparent, colourless, very mobile liquid, having a strong refracting power. Its specific gravity, according to Kopp (Pogg. Ann. lxxii. 1), is 0·792 at 20°; or 0·7939 at 15·5°, or 0·8095 at 0°. If its volume at 0° C. be taken for unity, the volume at any temperature t° is given by the formula:

$$v = 1 + 0{\cdot}00104139t + 0{\cdot}0000007836t^2 + 0{\cdot}000000017618t^3.$$

and therefore for the temperatures:

0° C. 5° C. 10° C. 15° C. 20° C. 25° C. 30° C.

the volumes of a given quantity of alcohol are as the numbers:

1·00000 1·00523 1·01052 1·01585 1·02128 1·02680 1·03242

Alcohol has never been reduced to the solid state, but becomes viscid at very low temperatures, as when it is surrounded with a mixture of solid carbonic acid and ether under an exhausted receiver. It boils at 78·4° C. (173·1° Fah.) when the barometer stands at 0·76 met. (Gay-Lussac, Kopp.) Vapour-density = 1·613 (Gay-Lussac); by calculation, for a condensation to 2 volumes, it is 1·591 when referred to air as unity, and 23 when referred to hydrogen as unity $\left(\frac{2 \times 12 + 6 \times 1 + 16}{2} = 23.\right)$ Alcohol has an enlivening odour and a burning taste, and when unmixed with water exerts a poisonous action. It is a very slow conductor of electricity.

Decompositions. 1. *By Heat.*—Alcohol-vapour passed through a red-hot glass or porcelain tube yields carbonic anhydride, water, hydrogen, marsh-gas, olefiant gas, naphthalin, empyreumatic oil and a deposit of charcoal. If the tube be filled with fragments of pumice-stone, the solid and liquid products consist of nalphthalin, benzol, hydrate of phenyl, acetic acid (?) and aldehyde, together with a number of solid compounds of not very definite character, some of them smelling like musk, others like garlic (Berthelot, Ann. Ch. Phys. [3] xxxiii. 285). Alcohol-vapour does not undergo decomposition at 300° C. in a tube containing fragments of porcelain, but gives off gas even at 220°, if the tube contains spongy platinum. (Reiset and Millon, Ann. Ch. Phys. [3] viii. 280.)

2. *By Electricity.*—Absolute alcohol scarcely conducts the voltaic current, but when potash or potassium is dissolved in it, decomposition takes place, hydrogen being

evolved at the negative pole and aldehyde-resin formed at the positive pole. (Connell.)

3. *By Oxygen.* — Alcohol is very inflammable, and burns in the air with a dull blue flame, yielding water and carbonic acid. It does not readily deposit soot, even when the supply of air is limited, but absolute alcohol deposits it more readily than ordinary spirit. Alcohol-vapour mixed with air explodes by contact with flame or by the electric spark.

Imperfect Combustion. — When alcohol or its vapour comes in contact with air, and at the same time with platinum or certain other metals, an imperfect oxidation of the alcohol takes place, the metal being generally heated to redness, and the alcohol being converted, partly into carbonic acid and water, partly into aldehyde, acetic acid, formic acid, acetal, and a peculiar compound having an excessively pungent odour. Some metals excite this action at ordinary temperatures, others only when more or less heated; but in all cases the action is more powerful as the metal is more finely divided and consequently exposes a larger surface to the alcohol-vapour. The most powerful action is exerted by *platinum black.* When this substance is shaken on paper moistened with alcohol, it makes a hissing noise and becomes red-hot, sometimes setting fire to the alcohol, or else continuing to glow, and inducing the slow combustion above mentioned. If the platinum be previously moistened with a small quantity of water, or at once covered completely with alcohol, the ignition is prevented, and the slow combustion induced with greater certainty. If a number of watch-glasses containing moist platinum black, be placed above a dish containing alcohol, and a bell jar open at top inverted over them, the alcohol turns sour in a few weeks, and is found to contain aldehyde, acetal, acetic acid, and acetic ether.

This action of platinum black affords an excellent means of discovering the presence of alcohol in the air or in watery liquids. The liquid, neutralised, if necessary, with alkali, to prevent the escape of volatile acids, is introduced into a retort, into the neck of which, and near the bulb, is thrust a little boat containing platinum black, and on each side of this boat is placed a piece of litmus paper, in contact with the platinum. The retort is then gently heated in the water-bath, when, if alcohol is present, its vapour will be converted into acetic acid by contact with the platinum black and the paper will be reddened (Buchheim). [Other volatile organic liquids might exert a similar action.]

Spongy platinum and clean platinum wire act in a similar manner to platinum black, but not so quickly. If a coil of platinum wire be placed round the wick of a spirit-lamp, the alcohol set on fire till the wire becomes red-hot, and the flame then blown out, the wire will continue to glow and the alcohol-vapour to burn slowly, producing acetic acid, aldehyde, &c. The same effect is produced by a ball of spongy platinum. This is the *lamp without flame,* or *glow lamp* of Sir H. Davy.

4. *By Chlorine.* — Chlorine gas is rapidly absorbed by alcohol, imparting to it a yellow colour and causing considerable rise of temperature, which, if the liquid is exposed to light, may even cause it to take fire. At the same time it rapidly abstracts hydrogen, which is partly replaced by chlorine, thereby producing hydrochloric acid, aldehyde, acetal, acetic acid, acetate of ethyl, chloride of ethyl, and finally chloral. The mixture of these substances, freed by washing with water from the soluble constituents, was formerly called *heavy hydrochloric ether.* The formation of these several products is represented by the following equations:

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + 2\,Cl = \underbrace{C^2H^4O}_{\text{Aldehyde.}} + 2\,HCl$$

$$\underbrace{C^2H^4O}_{\text{Aldehyde.}} + 6\,Cl = \underbrace{C^2HCl^3O}_{\text{Chloral.}} + 3\,HCl$$

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + HCl = \underbrace{C^2H^5Cl}_{\substack{\text{Chloride of}\\ \text{ethyl.}}} + H^2O$$

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + H^2O + 4\,Cl = \underbrace{C^2H^4O^2}_{\text{Acetic acid.}} + 4HCl$$

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + \underbrace{C^2H^4O^2}_{\text{Acetic acid.}} = \underbrace{C^2H^3O^2.C^2H^5}_{\text{Acetate of ethyl.}} + H^2O$$

Acetate of ethyl may also be formed by the direct action of chlorine on the alcohol; thus:

$$2\,C^2H^6O + 4Cl = C^2H^3O^2.C^2H^5 + 4\,HCl$$

The acetal, which is probably formed at the beginning of the process, according to the equation:

$$3C^2H^6O + 2\,Cl = C^6H^{14}O^2 + H^2O + 2HCl,$$

is for the most part subsequently converted into acetic acid:

$$C^6H^{14}O^2 + 4H^2O + 10Cl = 3C^2H^4O^2 + 10HCl.$$

When the action of the chlorine is continued for a long time, chloral is always the principal product.

Chlorine in presence of alkalis, converts alcohol into chloroform and carbonic anhydride:

$$C^2H^6O + 8Cl + O = CHCl^3 + 5HCl + CO^2.$$

The same products are formed by distilling dilute alcohol with hypochlorite of calcium (chloride of lime, bleaching powder). (See CHLOROFORM.)

Bromine acts upon alcohol in a similar manner to chlorine, producing bromal, hydrobromic acid, bromide of ethyl, bromide of carbon, formic acid, and other products not yet thoroughly examined. *Iodine* is at first dissolved by alcohol without decomposition, and forms a brown solution; but after a while, hydriodic acid is produced, and acting upon a portion of the alcohol, forms iodide of ethyl. An alcoholic solution of potash treated with iodine yields iodoform and iodide of potassium, the former of which compounds may be separated by water.

5. *Chloric acid*, in the concentrated state, sets fire to alcohol; when diluted, it forms acetic acid, the action being sometimes attended with evolution of chlorine. *Perchloric acid* mixes with alcohol without decomposition at ordinary temperatures, but the liquid when heated first gives off alcohol, then ether, and ultimately white vapours smelling like oil of wine, the residue at the same time turning black.

6. *Strong Nitric acid* decomposes alcohol, with great evolution of heat and brisk ebullition, a mixture of various elastic fluids, the *ethereal nitrous gas* of the older chemists, being evolved and an acid liquid remaining behind; if the nitric acid is dilute, the action does not take place without application of heat. Part of the nitric acid unites directly with the alcohol, forming nitrate of ethyl, but the greater part is reduced to nitrous acid which then forms nitrite of ethyl (nitrous ether) with a portion of the alcohol, while the remainder of the alcohol is oxidised and converted into aldehyde, acetic acid, formic acid, saccharic acid, oxalic acid, glyoxal, glyoxylic acid, and glycollic acid, together with water and carbonic anhydride, which escapes as gas, together with nitric oxide and the vapours of the more volatile among the compounds just mentioned. The formation of glyoxal, glyoxylic acid, and glycollic acids is represented by the equations:

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + 3O = \underbrace{C^2H^2O^2}_{\text{Glyoxal.}} + 2H^2O$$

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + 3O = \underbrace{C^2H^4O^3}_{\text{Glycollic acid.}} + H^2O$$

$$\underbrace{C^2H^2O^2}_{\text{Glyoxal.}} + O + H^2O = \underbrace{C^2H^4O^4}_{\substack{\text{Glyoxylic}\\ \text{acid.}}}$$

If urea be added to the mixture of nitric acid and alcohol so as to decompose the nitrous acid as fast as it is formed (see UREA), the chief product of the action is nitrate of ethyl $NO^3.C^2H^5$. Hydrocyanic acid has also been observed among the products of the action of nitric acid upon alcohol.

When strong alcohol is heated with red fuming nitric acid (containing nitrous acid) and nitrate of silver or mercuric nitrate is added, white fumes are given off, containing aldehyde and other oxidised products, and a crystalline deposit of fulminate of silver or mercury is formed, its production being due to the action of the nitrous acid on the alcohol: *e.g.*

$$\underbrace{C^2H^6O}_{\text{Alcohol.}} + \underbrace{(NO^2)^2Hg''}_{\substack{\text{Mercuric}\\ \text{nitrite.}}} = \underbrace{C^2N^2Hg''O^2}_{\substack{\text{Fulminate}\\ \text{of mercury.}}} + 3H^2O$$

But when a solution of mercury in nitric acid free from nitrous acid is added at a temperature below 100° C. to alcohol of sp. gr. 0·844, no action takes place at first; but on raising the temperature to 100°, a white crystalline precipitate is formed, which is a compound of mercuric nitrate with a nitrate of ethyl in which the whole of the hydrogen is replaced by mercury (Sobrero and Selmi; Gerhardt):

$$4NO^3H + 6Hg''O + 2C^2H^6O = \underbrace{(NO^3)^2Hg''.(NO^3)^2(C^4\overset{\prime\prime}{H}g^5).2H^2O}_{\text{Crystalline compound.}} + 6H^2O$$

7. *Sulphuric acid* forms with alcohol a number of products varying in quantity according to the proportions in which the two liquids are mixed, their degree of concentration, and the temperature to which the mixture is exposed.

Strong sulphuric acid mixes with alcohol, producing considerable evolution of heat, and forms ethyl-sulphuric or sulphovinic acid, the acid being at the same time brought to a greater state of dilution:

$$\underbrace{C^2H^5.H.O}_{\text{Alcohol.}} + SO^4.H^2 = \underbrace{SO^4.H.C^2H^5}_{\text{Ethyl-sulphuric acid.}} + H^2O$$

When the strongest sulphuric acid (sp. gr. 1·825) is digested for some time at a gentle heat, with excess of absolute alcohol, more than half the sulphuric acid is converted into ethyl-sulphuric acid. If the acid or the alcohol is diluted with water, a considerable quantity of the sulphuric acid remains unaltered. Sulphuric acid containing 1 at. water ($SO^4H^2.H^2O$) forms ethyl-sulphuric acid only when heated. As the formation of ethyl-sulphuric acid is necessarily accompanied by that of water, a certain portion of the sulphuric acid must always remain unconverted into ethyl-sulphuric acid.

Formation of Ether.—A mixture of 1 pt. alcohol, and from 1 to 2 pts. strong sulphuric acid heated in a distillatory apparatus, boils between 120° and 140° C., at first giving off ether, together with more or less undecomposed alcohol, then at 140° scarcely anything but ether, at 160° ether and water,—and at length when, in consequence of the decomposition of the alcohol, the proportion of sulphuric acid has become excessive, and the temperature rises above 160°, the mixture blackens and gives off olefiant gas together with sulphurous acid and other products hereafter to be mentioned. If however the alcohol be allowed to flow constantly into the vessel in a thin stream, so as to maintain the proportion of 5 pts. alcohol to 9 pts. sulphuric acid, the temperature remains constant at about 140°, no sulphurous acid or olefiant gas is formed, but the alcohol, as fast as it is supplied, is given off again in the form of ether and water.

The alcohol converts a molecule of sulphuric acid into ethyl-sulphuric acid and water, as above:

$$\underbrace{C^2H^5.H.O}_{\text{Alcohol.}} + \underbrace{SO^4.H^2}_{\text{Sulphuric acid.}} = \underbrace{SO^4.C^2H^5.H}_{\text{Ethyl-sulphuric acid.}} + \underbrace{H^2O}_{\text{Water.}}$$

and the ethyl-sulphuric acid coming in contact with another molecule of alcohol, yields ether and sulphuric acid:

$$\underbrace{SO^4.C^2H^5.H}_{\text{Ethyl-sulphuric acid.}} + \underbrace{C^2H^5.H.O}_{\text{Alcohol.}} = \underbrace{(C^2H^5)^2O}_{\text{Ether.}} + \underbrace{SO^4H^2}_{\text{Sulphuric acid.}}.$$

The sulphuric acid thus reproduced acts in like manner upon another molecule of alcohol, and in this way the process continues as long as the supply of alcohol is kept up. Etherification is therefore a continuous process, a given quantity of sulphuric acid being capable of etherifying a very large quantity of alcohol. The water, however does not all pass off as it is formed, so that the sulphuric acid becomes continually though slowly weaker, and consequently a continually larger quantity of alcohol passes over undecomposed with the ether and water.

The explanation just given of the process of etherification is due to **Williamson** (Chem. Soc. Qu. J. iv. 106, 229). Its correctness is strikingly exhibited by the analogous reaction which takes place between common alcohol and amyl-sulphuric acid. When amyl-alcohol is dissolved in sulphuric acid, amyl-sulphuric acid is produced:

$$C^5H^{11}.H.O + SO^4H^2 = SO^4.C^5H^{11}.H + H^2O.$$

Now, on heating this mixture and passing a stream of ordinary alcohol through it, as above, ethamylic ether, or oxide of ethyl and amyl passes over first, then common ether, and ethyl-sulphuric acid remains behind in place of amyl-sulphuric acid:

$$\underbrace{SO^4.C^5H^{11}.H}_{\text{Amyl-sulphuric acid.}} + \underbrace{C^2H^5.H.O}_{\text{Alcohol.}} = \underbrace{C^2H^5.C^5H^{11}.O}_{\text{Oxide of ethyl and amyl.}} + \underbrace{SO^4H^2}_{\text{Sulphuric acid.}}$$

The sulphuric acid thus reproduced acts upon the ethyl-alcohol in the manner already described, the products being ethyl-sulphuric acid, ether, and water. The same products are obtained by distilling a mixture of ethyl-alcohol and amyl-alcohol with sulphuric acid.

The formation of ether from alcohol was formerly regarded as a simple process of dehydration. Ether being regarded as C^4H^5O and alcohol as its hydrate, $C^4H^5O.HO$, it was supposed that the sulphuric acid simply abstracted the water and left the ether. Against this view, however, it must be alleged that the quantity of water given off in the distillation is very nearly equal to the whole quantity supposed to be separated from the alcohol, which could not be the case if it were retained by the sulphuric acid. Moreover, the molecule of ether referred to the same vapour-volume as that of alcohol,

$C^4H^6O^2$, is not C^4H^5O, but $C^8H^{10}O^2$; or, according to the atomic weights adopted in this work, alcohol being C^2H^6O, ether is $C^4H^{10}O$. For these reasons, Mitscherlich, Berzelius, and other chemists have regarded the action of sulphuric acid upon alcohol as a *contact-action*, or *catalytic action*, a mode of expression which simply states the fact without explaining it.

Another objection to the views just mentioned, is that they take no account of the formation of ethyl-sulphuric acid. That this, however, is an essential step in the process of etherification is shown by the fact that, on distilling a mixture of alcohol and strong sulphuric acid, the quantity of ethyl-sulphuric acid constantly diminishes as the ether passes over, and that, if the acid be diluted so far as not to form ethyl-sulphuric acid, the mixture yields no ether by distillation. Liebig therefore supposed that the ethyl-sulphuric acid is resolved at a certain temperature (120° to 140° C.) into ether, sulphuric acid, and sulphuric anhydride:

$$2(C^2H^5.H.SO^4) = C^4H^{10}O + SO^4H^2 + SO^3$$

and that the sulphuric anhydride, uniting with water also present in the mixture, reproduces sulphuric acid. But ethyl-sulphuric acid when heated alone gives off, not ether but alcohol, even when heated to 140° or above in sealed tubes; but when heated with alcohol, it immediately yields ether. We are therefore led to regard the formation of ether as a result of the mutual decomposition of alcohol and ethyl-sulphuric acid, in the manner already explained.

When alcohol and strong sulphuric acid are heated together in sealed tubes, the alcohol being in excess, a layer of ether forms on the top of the liquid, but no ethyl-sulphuric acid is found in the lower stratum. If the sulphuric acid is in excess, no ether is formed (Graham, Chem. Soc. Qu. J. iii. 24). In the former case, it is probable that ethyl-sulphuric acid was first formed, and afterwards converted by the excess of alcohol into ether and sulphuric acid. Acid sulphate of potassium (Graham) and various other sulphates heated with alcohol in sealed tubes, also etherify it more or less completely, the sulphate being in some cases converted into a basic salt. The alums, namely common alum, ammonia-alum, potassio-ferric sulphate, and potassio-chromic sulphate heated with an equal weight of 98 per cent. alcohol, etherify it completely. In all these cases, the sulphate appears to give up a portion of its sulphuric acid, which then acts on the alcohol as above. (Reynoso, Ann. Ch. Phys. [3] xxviii. 385.)

Formation of Olefiant gas.—When 1 pt. of alcohol is heated with 3 or 4 pts. of strong sulphuric acid, the mixture begins, between 160° and 180° C., to blacken and thicken, swells up considerably and gives off olefiant gas C^2H^4, together with variable quantities of sulphurous anhydride, carbonic anhydride, carbonic oxide, oil of wine, acetic acid, acetic ether and formic acid, and a black residue is ultimately left consisting of a peculiar acid called thiomelanic acid and free sulphuric acid. By passing alcohol-vapour through a boiling mixture of 10 pts. of strong sulphuric acid and 3 pts. of water, olefiant gas and water are obtained, with scarcely any coloration of the mixture or formation of secondary products:

$$C^2H^6O = C^2H^4 + H^2O.$$

8. *Sulphuric anhydride*, SO^3, is dissolved by absolute alcohol, with evolution of heat, and forms neutral sulphate of ethyl $SO^4.(C^2H^5)^2$. When the vapour of the anhydride is passed into absolute alcohol, crystals of sulphate of carbyl, $C^2H^4.2SO^3$, are formed, together with ethionic, isethionic, ethyl-sulphuric and sulphuric acids.

9. *Phosphoric acid* mixed with alcohol at ordinary temperatures, converts part of it into ethyl-phosphoric acid. A mixture of phosphoric acid with a small quantity of alcohol yields olefiant gas but no ether; but if the alcohol is in excess, ether is first given off, then olefiant gas and a thick acid distillate probably consisting of neutral phosphate of ethyl, $PO^4.(C^2H^5)^3$. *Phosphoric anhydride* absorbs the vapour of anhydrous alcohol, forming ethyl-phosphoric acid $PO^4.C^2H^5.H^2$, and diethylphosphoric acid, $PO^4.(C^2H^5)^2.H$. *Arsenic acid* acts very much like phosphoric acid, producing ether and ethyl-arsenic acid. *Boric anhydride* (vitrefied boric acid) in the state of powder heated with absolute alcohol, gives off olefiant gas and leaves boric acid.

10. *Hydrochloric* acid gas is absorbed in large quantity by alcohol, and the solution when heated gives off chloride of ethyl. The same compound is obtained by distilling alcohol with strong hydrochloric acid, or with a mixture of common salt and sulphuric acid; but when a mixture of hydrochloric acid with a large excess of alcohol, either anhydrous or hydrated, is heated to 240° in a sealed tube, ether is formed as well as chloride of ethyl, these two liquids forming a layer on the surface, while the lower stratum consists chiefly of water and hydrochloric acid. The ether results from the action of alcohol on the chloride of ethyl already formed:

$$C^2H^5.Cl + C^2H^5.H.O = (C^2H^5)^2O + HCl.$$

The same transformation takes place, though slowly, even at 100° C. (A. Reynoso, Ann. Ch. Phys. [3] xlviii. 385.)

11. Many *metallic chlorides* act upon alcohol in a similar manner to hydrochloric acid, producing ether and chloride of ethyl. *Chloride of zinc* converts anhydrous alcohol into chloride of ethyl with a small quantity of ether. With hydrated alcohol, it yields at 155°C., ether and oil of wine, the quantity of which increases as the distillation goes on; hydrochloric acid is also given off, and basic chloride of zinc remains. When dichloride of tin is distilled with a considerable quantity of alcohol, ether and chloride of ethyl pass over between 140° and 170°, afterwards a compound of chloride of ethyl with dichloride of tin. (Kuhlmann, Ann. Ch. Pharm. xxxiii. 97, 192.)

Crystallised *protochloride of tin* distilled with alcohol yields ether, but no chloride of ethyl (Marchand); the same decomposition takes place in a sealed tube at 240°. Crystallised *chloride of manganese* and *protochloride of iron* also etherify alcohol completely when heated with it in sealed tubes to 240°; the chlorides of *cadmium, nickel, and cobalt* partially; in all these cases, the etherification takes place without blackening of the contents of the tube, and with little or no escape of gas when it is opened (Reynoso, Ann. Ch. Phys. [2] xlviii. 385). The formation of ether in these reactions, may be explained by the following equations, given by Williamson for the case of chloride of zinc:

$$
\begin{aligned}
2(C^2H^5O.H) &+ Zn''Cl^2 = (C^2H^5O)^2Zn'' + 2HCl.\\
C^2H^5.H.O &+ HCl = C^2H^5.Cl + H^2O.\\
2(C^2H^5.Cl) &+ (C^2H^5O)^2Zn'' = 2(C^2H^5)^2O + Zn''Cl^2.
\end{aligned}
$$

With *sesquichloride of iron*, alcohol yields ether and chloride of ethyl between 130° and 140°C., afterwards hydrochloric acid and water, the residue consisting of sesquichloride of iron mixed with sesquioxide. With *chloride of aluminium*, chloride of ethyl is given off between 170° and 200°, afterwards hydrochloric acid, and alumina is left behind. *Trichloride* and *pentachloride of antimony* convert alcohol into chloride of ethyl, with a little ether, the residue consisting chiefly of oxychloride of antimony.

Dichloride of platinum boiled with alcohol of sp. gr. 0·813 to 0·893 is converted into a black explosive powder called *detonating platinum-deposit*, $C^2H^4Pt^2O$, the liquid acquiring a strong acid reaction and the odour of chloride of ethyl:

$$C^2H^6O + Pt''Cl^2 = C^2H^4Pt''O + 2HCl.$$

The chloride of ethyl is formed by the action of the hydrochloric acid on another portion of the alcohol. (Zeise.)

A solution of 1 pt. of *tetrachloride of platinum* in 10 pts. of alcohol of sp. gr. 0·823, distilled to $\frac{1}{6}$, yields aldehyde, chloride of ethyl, and hydrochloric acid. The residual dark brown liquid deposits a considerable quantity of the black detonating powder just mentioned, and retains in solution the so-called *inflammable chloride of platinum*, $C^2H^4PtCl^2$, according to Zeise, or $C^2H^3PtCl^2$, according to Liebig. Its formation is represented by one of the following equations:

$$2C^2H^6O + PtCl^4 = C^2H^4PtCl^2 + \underbrace{C^2H^4O}_{\text{Aldehyde.}} + H^2O + 2HCl. \quad \text{(Zeise.)}$$

$$3C^2H^6O + 2PtCl^4 = 2C^2H^3PtCl^2 + \underbrace{C^2H^4O}_{\text{Aldehyde.}} + 2H^2O + 4HCl. \quad \text{(Liebig.)}$$

The formation of the black deposit is not an essential part of the reaction, and indeed takes place most abundantly when the dichloride of platinum contains protochloride.

Mercuric chloride, $HgCl^2$, dissolved in alcohol is slowly reduced to mercurous chloride Hg^2Cl^2. Potash added in excess to the alcoholic solution heated to 50° C., forms an amorphous yellow precipitate containing carbon, hydrogen, oxygen and mercury, the hydrogen being in smaller proportion than in alcohol. This precipitate heated to 200°, explodes without leaving any residue; heated in the moist state, it decomposes less violently, yielding mercury, water, and acetic acid (Sobrero and Selmi). Gerhardt and Werther did not succeed in preparing this compound.

12. *Trichloride of phosphorus* readily decomposes alcohol, forming chloride of ethyl, hydrochloric acid, tribasic phosphite of ethyl and phosphorous acid. (Béchamp Compt. rend. xl. 944.)

$$6(C^2H^5.H.O) + 2\,PCl^3 = 3C^2H^5Cl + 3\,HCl + PO^3.(C^2H^5)^3 + PO^3.H^3.$$

13. With *pentachloride* of phosphorus, the products are chloride of ethyl, hydrochloric and chlorophosphoric acid, PCl^3O:

$$C^2H^5.H.O + PCl^3.Cl^2 = C^2H^5Cl + HCl + PCl^3.O.$$

14. *Pentasulphide of phosphorus*, on the other band, converts alcohol, not into two separate sulphides, but into the single compound *mercaptan*, or sulphide of ethyl and hydrogen:

$$5(C^2H^5.H.O) + P^2S^5 = 5(C^2H^5.H.S) + P^2O^5.$$

These last two reactions illustrate in a striking manner, the difference between monatomic and diatomic elements or radicles. In the former, the single atom of oxygen in alcohol is replaced by two atoms of chlorine, one of which unites with the ethyl, and the other with the hydrogen of the alcohol, forming two perfectly distinct chlorides; whereas in the latter, the oxygen of the alcohol is replaced by 1 atom of the diatomic element, sulphur, which being indivisible, binds together the ethyl and hydrogen into one single molecule of mercaptan. (Compare page 11.)

15. The *bromides* and *iodides* of phosphorus, hydrogen, and the metals, act like the chlorides. *Hydrofluoric* acid appears to convert alcohol into fluoride of ethyl.

16. *Potassium* and *sodium* rapidly decompose absolute alcohol, 1 atom of hydrogen being evolved and its place supplied by the metal; the resulting compound is an ethylate of potassium (C^2H^5KO) or ethylate of sodium, which crystallises from the saturated solution. The same compound appears to be formed by dissolving hydrate of potassium or sodium in absolute alcohol:

$$C^2H^5.H.O + KHO = C^2H^5.K.O + H^2O$$

The solution thus obtained exhibits in many cases the same reactions as that which is produced by dissolving the metal in alcohol.

17. Alcohol heated with *hydrate of potassium* (or sodium) yields hydrogen gas and an acetate:

$$C^2H^6O + KHO = C^2H^3KO^2 + 4H.$$

To produce this decomposition, a mixture of equal weights of the alkaline hydrate and pounded quick lime is moistened with alcohol, the excess of alcohol driven off at 100°, and the mixture gently heated without access of air. Hydrogen is then evolved, together with a small quantity of marsh gas, and the residue contains acetate of potassium, which, at a higher temperature, is resolved into marsh gas and carbonate of potassium (p. 17).

18. Alcohol-vapour passed over *anhydrous baryta* heated nearly to redness, yields olefiant gas, marsh gas and hydrogen, with a residue of carbonate of barium.

19. Gaseous *chloride of cyanogen* is readily absorbed by alcohol, but does not decompose it immediately. After a few days however, or more quickly if a little water is present or if the liquid is heated to 80°, chloride of ammonium separates out, while chloride of ethyl, carbamate of ethyl (urethane) and carbonate of ethyl remain in solution. The urethane and carbonate of ethyl are formed in the manner represented by the two following equations:

$$C^2H^6O + CNCl + H^2O = \underbrace{C^3H^7NO^2}_{\text{Urethane.}} + HCl$$

$$2C^2H^6O + CNCl + H^2O = \underbrace{CO^3(C^2H^5)^2}_{\text{Carbonate of ethyl.}} + NH^4Cl$$

The chloride of ethyl results from the action of the hydrochloric acid, produced as in the first equation, on the alcohol. (Wurtz. Ann. Ch. Pharm. lxxix. 77.)

20. Many *organic acids* when heated with alcohol convert it into compound ethers, with elimination of 1, 2, or 3 atoms of water, according as the acid is monobasic dibasic, or tribasic: *e. g.*

$$\underbrace{C^2H^5.H.O}_{\text{Alcohol.}} + \underbrace{C^2H^3O.H.O}_{\text{Acetic acid.}} = \underbrace{C^2H^3O.C^2H^5.O}_{\text{Acetic ether.}} + H^2O$$

$$\underbrace{2(C^2H^5.H.O)}_{\text{Alcohol.}} + \underbrace{CO^2.H^2.O^2}_{\text{Oxalic acid.}} = \underbrace{CO^2(C^2H^5)^2O^2}_{\text{Oxalic ether.}} + 2H^2O$$

$$\underbrace{3(C^2H^5.H.O)}_{\text{Alcohol.}} + \underbrace{C^6H^5O^4.H^3.O^3}_{\text{Citric acid.}} = \underbrace{C^6H^5O^4.(C^2H^5)^3.O^3}_{\text{Citric ether.}} + 3H^2O$$

With some acids, *e. g.* acetic and butyric acids, the transformation is easily effected; with others, as oxalic and hippuric acid, it takes a considerable time: in other cases again, as with benzoic acid, no ether is formed when the acid and the alcohol are merely

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Dichloride of platinum boiled with alcohol of sp. gr. 0·813 to 0·893
into a black explosive powder called *detonating platinum-deposit*, C^2H^4Pt
acquiring a strong acid reaction and the odour of chloride of ethyl:

$$C^2H^6O + Pt''Cl^2 = C^2H^4Pt''O + 2HCl.$$

The chloride of ethyl is formed by the action of the hydrochloric acid on
tion of the alcohol. (Zeise.)

A solution of 1 pt. of *tetrachloride of platinum* in 10 pts. of alcohol of
distilled to ⅛, yields aldehyde, chloride of ethyl, and hydrochloric acid.
dark brown liquid deposits a considerable quantity of the black deton
just mentioned, and retains in solution the so-called *inflammable chloride*
$C^2H^4PtCl^2$, according to Zeise, or $C^2H^8PtCl^2$, according to Liebig.
is represented by one of the following equations:

$$2C^2H^6O + PtCl^4 = C^2H^4PtCl^2 + \underbrace{C^2H^4O}_{\text{Aldehyde.}} + H^2O + 2HCl. \quad ($$

$$3C^2H^6O + 2PtCl^4 = 2C^2H^8PtCl^2 + \underbrace{C^2H^4O}_{\text{Aldehyde.}} + 2H^2O + 4HCl. \quad ($$

The formation of the black deposit is not an essential part of the :
indeed takes place most abundantly when the dichloride of platinum co
chloride.

Mercuric chloride, $HgCl^2$, dissolved in alcohol is slowly reduced to merc
Hg^2Cl^2. Potash added in excess to the alcoholic solution heated to 50° C., fo
phous yellow precipitate containing carbon, hydrogen, oxygen and mercury
being in smaller proportion than in alcohol. This precipitate heated to
without leaving any residue; heated in the moist state, it decomposes
yielding mercury, water, and acetic acid (Sobrero and Selmi).
Werther did not succeed in preparing this compound.

12. *Trichloride of phosphorus* readily decomposes alcohol, forming chl
hydrochloric acid, tribasic phosphite of ethyl and phosphorous acid.
Compt. rend. xl. 944.)

$$6(C^2H^5.H.O) + 2PCl^3 = 3C^2H^5Cl + 3HCl + PO^3.(C^2H^5)^3 + P$$

13. With *pentachloride* of phosphorus, the products are chloride of
chloric and chlorophosphoric acid, PCl^3O:

$$C^2H^5.H.O + PCl^3.Cl^2 = C^2H^5Cl + HCl + PCl^3.O.$$

The alcohol in all these compounds may be regarded as analogous to water of crystallisation.

ALCOHOL-BASES. This name is frequently applied to the organic bases produced by the substitution of alcohol-radicles for the hydrogen in ammonia; such, as ethylamine, phenylamine, &c. (See AMINES.)

ALCOHOLOMETRY. (*Alcoométrie.*) The value of spirituous liquors depends upon the quantity of alcohol which they contain. This may be determined in various ways: viz. by the specific gravity of the mixture, by its boiling-point, by the tension of its vapour, by its rate of expansion, and by estimating the proportion of carbon contained in it by combustion with oxide of copper. But of all these methods, that which depends upon the density is almost always employed for practical purposes, other methods being resorted to only when the mixture of alcohol and water is associated with foreign substances, such as sugar, or colouring matter, or salts, in sufficient quantity to produce a material alteration of the density.

To determine the amount of alcohol in a spirituous liquor by its density, it is necessary to know beforehand the density corresponding to each particular proportion of alcohol and water. If these liquids were capable of mixing without alteration of volume, the specific gravity of each particular mixture might be calculated from the proportions of alcohol and water contained in it, and the known specific gravity of absolute alcohol. This however is not the case, the combination of alcohol and water being attended with a contraction of volume varying in amount with the temperature. For this reason the specific gravity of each mixture of alcohol and water must be determined by direct experiment, and the results collected in tables.

The importance of this object for the purposes of revenue induced the British government to employ Sir Charles Blagden to institute a very extensive and accurate series of experiments on the density of spirit of various degrees of strength. The determinations, which were made by Gilpin under Blagden's direction, were first published in 1790, afterwards twice repeated to obtain greater accuracy, and published in the Philosophical Transactions for 1794.

The specific gravity of the mixtures of alcohol and water was determined by accurately weighing a quantity of the liquid in a flask having a long narrow neck, and filled with it up to a certain mark, the weight of an equal quantity of distilled water having been previously ascertained. In this manner, the specific gravity of 40 mixtures was determined, each at 15 different temperatures. The standard alcohol used to mix with the water was not absolute, but had a specific gravity of 0·82514; for convenience, however, it was supposed to be = 0·825, a corresponding deduction being made from all the numbers in the table.

TABLE I.—*Showing the Specific Gravity of various mixtures of Alcohol (of Specific Gravity* 82500 *at* 60° *Fahr.) and Water at different Temperatures, the Specific Gravity of water at* 60° *Fahr. being* 100000.

Heat.	The pure spirit.	100 grains of spirit to 5 gr. of water.	100 grains of spirit to 10 gr. of water.	100 grains of spirit to 15 gr. of water.	100 grains of spirit to 20 gr. of water.	100 grains of spirit to 25 gr. of water.	100 grains of spirit to 30 gr. of water.	100 grains of spirit to 35 gr. of water.	100 grains of spirit to 40 gr. of water.	100 grains of spirit to 45 gr. of water.	100 grains of spirit to 50 gr. of water.
30 F.	·83896	·84995	·85957	·86825	·87585	·88282	·88921	·89511	·90054	90558	·91023
35	83672	84769	85729	86587	87357	88059	88701	89294	89839	90345	90811
40	83445	84539	85507	86361	87184	87838	88481	89073	89617	90127	90596
45	83214	84310	85277	86131	86905	87613	88255	88849	89396	89909	90380
50	82977	84076	85042	85902	86676	87384	88030	88626	89174	89684	90160
55	82736	83834	84802	85664	86441	87150	87796	88393	88945	89458	89933
60	82500	83599	84568	85430	86208	86918	87569	88169	88720	89232	89707
65	82262	83362	84334	85193	85976	86686	87337	87938	88490	89006	89479
70	82023	83124	84092	84951	85736	86451	87105	87705	88254	88773	89252
75	81780	82878	83851	84710	85496	86212	86864	87466	88018	88538	89018
80	81530	82631	83603	84467	85248	85966	86622	87228	87776	88301	88781
85	81291	82396	83371	84243	85036	85757	86411	87021	87590	88120	88609
90	81044	82150	83126	84001	84797	85518	86172	86787	87360	87889	88376
95	80794	81900	82877	83753	84550	85272	85928	86542	87114	87654	88146
100	80548	81657	82639	83513	84038	85031	85688	86302	86879	87421	87915

distilled together; but on passing hydrochloric gas into the alcoholic solution of the acid, the ether is quickly formed. In this case, chloride of ethyl is first formed and afterwards decomposed by the organic acid. Other strong mineral acids, such as sulphuric acid, also facilitate the formation of these compound ethers.

Many polybasic organic acids form acid ethers when digested with alcohol; thus tartaric acid forms ethyl-tartaric acid $C^4H^4O^4(C^2H^5.H)O^2$.

The anhydrides of monobasic acids quickly convert alcohol into the corresponding ethers. (See *Dictionary of Arts, Manufactures, and Mines.*)

Compounds of Alcohol. Alcohol has a very strong affinity for *water*, and mixes with it in all proportions. The mixture is attended with slight evolution of heat, and also with contraction of volume, which gradually increases till the mixture contains 116 pts. water to 100 pts. alcohol. Strong alcohol absorbs moisture from the air. It abstracts water from the moist parts of the animal body, and coagulates them if they are of albuminous nature; hence its use in the preservation of anatomical preparations. From the same cause it destroys life in the veins.

Alcohol dissolves *iodine* and *bromine*; also *sulphur* and *phosphorus* in small quantities. *Gases* for the most part dissolve in alcohol more readily than in water. (See GASES, ABSORPTION OF.) Salts are, generally speaking, less soluble in alcohol than in water; indeed many salts quite insoluble in alcohol are easily soluble in water; *e. g.* the alkaline carbonates and sulphates. Chloride of mercury is, however, an exception to the general rule, being more soluble in alcohol than in water. Inorganic compounds, sparingly soluble in water, are, for the most part, quite insoluble in alcohol; so likewise are efflorescent compounds. But all deliquescent salts, excepting carbonate and phosphate of potassium and a few others, are soluble in alcohol.

Since alcohol does not dissolve all compounds which are soluble in water, it follows that many substances, when dissolved in alcohol, do not exhibit the same reactions towards other substances as when dissolved in water. Thus many acids, when dissolved in absolute alcohol do not redden litmus or decompose carbonate of barium or calcium, probably because the resulting calcium or barium salt would be insoluble in alcohol.

Alcohol readily dissolves *resins, ethers, essential oils, fats, alkaloids*, many *organic acids*, and in general, all substances containing a larger proportion of hydrogen.

ALCOHOLATES. Alcohol unites in definite proportion with several salts, forming crystallisable compounds, which however have but little stability and are almost all decomposed by water. These compounds were first obtained by Graham. (Graham, Phil. Mag. Ann. iv. 265. 331; Einbrodt, Ann. Ch. Pharm. lxv. 115.; Chodnew, ibid. lxxi. 241; Lewy, Compt. rend. xxi. 371; Robiquet, J. Pharm. [3] xxvi. 161.)

Nitrate of magnesium dissolved in alcohol forms, on cooling from a boiling hot solution, a crystalline mass like margarin, containing $6C^2H^6O.(NO^3)^2Mg$.

Fused *chloride of calcium* dissolves in absolute alcohol, and the solution, if surrounded with ice, deposits crystals containing $4C^2H^6O.CaCl^2$. This compound subjected to dry distillation yields nothing but carburetted hydrogen. If the alcohol contains a small quantity (about 1 per cent.) of water, the solution yields by evaporation sometimes a crystalline mass, sometimes a syrup, which dries up in vacuo to a white amorphous mass. Both the crystals and the syrup contain $4C^2H^6O.3CaCl^2 + 2H^2O$.

Chloride of zinc forms with absolute alcohol a crystalline compound which contains $C^2H^6O.ZnCl$, and yields when heated, alcohol, chloride of ethyl, hydrochloric acid and oxide of zinc, but no ether.

Dichloride of tin and absolute alcohol, brought together in a vessel immersed in a freezing mixture, unite immediately, and on evaporating the solution in vacuo, over sulphuric acid and sticks of potash, crystals are formed containing $4C^2H^6O.Sn^2Cl^6O$. The crystals are very soluble in alcohol. They distil at 80° almost without decomposition (Lewy.) By cooling a mixture of 11·5 pts. of anhydrous alcohol, and 32·4 pts. of dichloride of tin in a frigorific mixture, Robiquet obtained a white powder which, when dissolved in alcohol, yielded by evaporation in vacuo over sulphuric acid, crystals containing $2C^2H^6O.SnCl^4$.

With *baryta*, alcohol forms the compound $2C^2H^6O.BaO$, which is obtained by adding anhydrous baryta to absolute alcohol, filtering, and again adding baryta. If the alcoholic solution be then boiled, the compound separates in the form of a granular precipitate which redissolves on cooling. Water added to the solution throws down hydrate of barium. (Berthelot, Ann. Ch. Phys. [3] xlvi. 222.)

The following substances also form crystalline compounds with alcohol: sesquichloride of iron, protochloride of iron nitrate of calcium, and protochloride of manganese. (Graham.)

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Heat.	The pure spirit.	100 grains of spirit to 5 gr. of water.	100 grains of spirit to 10 gr. of water.	100 grains of spirit to 15 gr. of water.	100 grains of spirit to 20 gr. of water.	100 grains of spirit to 25 gr. of water.	100 grains of spirit to 30 gr. of water.	100 grains of spirit to 35 gr. of water.	100 grains of spirit to 40 gr. of water.	100 grains of spirit to 45 gr. of water.	100 grains of spirit to 50 gr. of water.
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40	83445	84539	85507	86361	87184	87838	88481	89073	89617	90127	90596
45	83214	84310	85277	86131	86905	87613	88255	88849	89396	89909	90380
50	82977	84076	85042	85902	86676	87384	88030	88626	89174	89684	90160
55	82736	83834	84802	85664	86441	87150	87796	88393	88945	89458	89933
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80	81530	82631	83603	84467	85248	85966	86622	87228	87776	88301	88781
85	81291	82396	83371	84243	85036	85757	86411	87021	87590	88120	88609
90	81044	82150	83126	84001	84797	85518	86172	86787	87360	87889	88376
95	80794	81900	82877	83753	84550	85272	85928	86542	87114	87654	88146
100	80548	81657	82639	83513	84038	85031	85688	86302	86879	87421	87915

TABLE I. (*continued*).

Heat	100 grains of spirit to 55 gr. of water.	100 grains of spirit to 60 gr. of water.	100 grains of spirit to 65 gr. of water.	100 grains of spirit to 70 gr. of water.	100 grains of spirit to 75 gr. of water.	100 grains of spirit to 80 gr. of water.	100 grains of spirit to 85 gr. of water.	100 grains of spirit to 90 gr. of water.	100 grains of spirit to 95 gr. of water.	100 grains of spirit to 100 gr. of water.
30° F.	·91449	·91847	·92217	·92563	·92889	·93191	·93474	·93741	·93991	·94222
35	91241	91640	92009	92355	92680	92986	93274	93541	93790	94025
40	91026	91428	91799	92151	92476	92783	93072	93341	93592	93827
45	90812	91211	91584	91937	92264	92570	92859	93131	93382	93621
50	90596	90997	91370	91723	92051	92358	92647	92919	93177	93419
55	90367	90768	91144	91502	91837	92145	92436	92707	92963	93208
60	90144	90549	90927	91287	91622	91933	92225	92499	92758	93002
65	89920	90328	90707	91066	91400	91715	92010	92283	92546	92794
70	89695	90104	90484	90847	91181	91493	91793	92069	92333	92580
75	89464	89872	90252	90617	90952	91270	91569	91849	92111	92364
80	89225	89639	90021	90385	90723	91046	91340	91622	91891	92142
85	89043	89460	89843	90209	90558	90882	91186	91465	91729	91969
90	88817	89230	89617	89988	90342	90668	90967	91248	91511	91751
95	88588	89003	89390	89763	90119	90443	90747	91029	91290	91531
100	88357	88769	89158	89536	89889	90215	90522	90805	91066	91310

Heat.	95 grains of spirit to 100 gr. of water.	90 grains of spirit to 100 gr. of water.	85 grains of spirit to 100 gr. of water.	80 grains of spirit to 100 gr. of water.	75 grains of spirit to 100 gr. of water.	70 grains of spirit to 100 gr. of water.	65 grains of spirit to 100 gr. of water.	60 grains of spirit to 100 gr. of water.	55 grains of spirit to 100 gr. of water.	50 grains of spirit to 100 gr. of water.
30° F.	·94447	·94675	·94920	·95173	·95429	·95681	·95944	·96209	·96470	·96719
35	94249	94484	94734	94988	95246	95502	95772	96048	96315	96579
40	94058	94295	94547	94802	95060	95328	95602	95879	96159	96434
45	93860	94096	94348	94605	94871	95143	95423	95703	95993	96280
50	93658	93897	94149	94414	94683	94958	95243	95534	95831	96126
55	93452	93696	93948	94213	94486	94767	95057	95357	95662	95966
60	93247	93493	93749	94018	94296	94579	94876	95181	95493	95804
65	93040	93285	93546	93822	94099	94388	94689	95000	95318	95635
70	92829	93076	.93337	93616	93898	94193	94500	94813	95139	95469
75	92613	92865	93132	93413	93695	93989	94301	94623	94957	95292
80	92393	92646	92917	93201	93488	93785	94102	94431	94768	95111

Heat.	45 grains of spirit to 100 gr. of water.	40 grains of spirit to 100 gr. of water.	35 grains of spirit to 100 gr. of water.	30 grains of spirit to 100 gr. of water.	25 grains of spirit to 100 gr. of water.	20 grains of spirit to 100 gr. of water.	15 grains of spirit to 100 gr. of water.	10 grains of spirit to 100 gr. of water.	5 grains of spirit to 100 gr. of water.
30° F.	·96967	·97200	·97418	·97635	·97860	98108	·98412	·98814	·99334
35	96840	97086	97319	97556	97801	98076	98397	98804	99344
40	96706	96967	97220	97472	97737	98033	98373	98795	99345
45	96563	96840	97110	97384	97666	97980	98338	98774	99338
50	96420	96708	96995	97284	97589	97920	98293	98745	99316
55	96272	96575	96877	97181	97500	97847	98239	98702	99284
60	96122	96437	96752	97074	97410	97771	98176	98654	99244
65	95962	96288	96620	96959	97309	97688	98106	98594	99194
70	95802	96143	96484	96836	97203	97596	98028	98527	99134
75	95638	95987	96344	96708	97086	97495	97943	98454	99066
80	95467	95826	96192	96568	96963	97385	97845	98367	98991

Gilpin's tables do not give directly the quantity of absolute alcohol contained in spirit of any given density. In this respect, however, they have been completed by the experiments of Tralles, who in 1811 (Gilbert's Annalen, xxxviii. 386), determined the specific gravity of alcohol, dehydrated as completely as possible by means of chloride of calcium, and likewise the strength of Gilpin's standard spirit, having a specific gravity of 0·825 at 60° F. He found that the specific gravity of absolute alcohol at 60° F. compared with that of water at its maximum density is 0·7939 (or 0·7946 compared with water at 60°) and that Gilpin's standard spirit contains in 100 parts by weight, 89·2 parts of anhydrous alcohol, and 10·8 parts of water. Proceeding upon these data, Tralles calculated the proportions of absolute alcohol and water contained in spirit of various densities; the results are given in Table II. p. 83.

The proportions of alcohol in spirit of wine may be expressed either by weight or by volume. The former mode of expression is by far the simpler and more definite, because the proportion by weight is independent of the temperature, whereas the proportion by volume varies with the temperature, being affected by the different rates of expansion of alcohol and water. For scientific purposes, therefore, the strength of spirit is always expressed in percentage by weight. In commerce, on the contrary, the method by volume is always adopted, spirit being generally bought and sold by measure, not by weight. It becomes therefore necessary to know how to calculate the composition by volume from the composition by weight and the observed specific gravity.

Let S be the specific gravity of the spirit (mixture of alcohol and water): a the quantity of alcohol in 100 parts by weight, and therefore $100 - a$ the quantity of water; V the volume of the spirit referred to a unit of volume, such that a quantity of water which fills it is the unit of weight (*e. g.* if the weight is expressed in grammes, V is measured in cubic centimetres) then:

$$100 = V \,.\, S$$

If then, the specific gravity of anhydrous alcohol at the observed temperature compared with water at the same temperature be s, the volumes of alcohol and water contained in the spirit are:

$$\frac{a}{s} \quad \text{and} \quad 100 - a$$

and consequently, the proportions of alcohol and water in 100 volumes of the spirit are:

$$\frac{a}{s} \cdot \frac{100}{V} = a. \frac{S}{s} \text{ volumes of alcohol.}$$

$$\text{and: } (100-a) \cdot \frac{100}{V} = (100 - a)\, S \text{ volumes of water.}$$

For example: from the table p. 85 it appears that spirit containing 77·09 per cent. of alcohol by weight has at 60° F. a sp. gr. of 0·8555, referred to water at the same temperature, and the specific gravity of absolute alcohol referred to the same standard is 0·7946: hence the percentage of alcohol by volume is:

$$77{\cdot}09 \cdot \frac{8555}{7946} = 83{\cdot}00$$

and the percentage by volume of water is:

$$(100 - 77{\cdot}09) \,.\, 0{\cdot}8555 = 22{\cdot}91 \,.\, 0{\cdot}8555 = 20{\cdot}60$$

the whole being measured at 60° F.

The volumes of alcohol and water thus obtained amount together to more than 100, in the preceding example to 103·60; and accordingly, if 83·00 measures of alcohol be mixed with 20·60 measures of water, both at 60° F., the mixture, after it has cooled to 60° F., will fill exactly 100 measures, and the spirit thus produced will contain 83 volumes per cent. of alcohol. (Respecting the contraction which takes place on mixing alcohol and water in various proportions, see Rudberg, Pogg. Ann. xiii. 196; also Kopp, ibid. liii. 356.)

When the volume per cent. in a mixture of alcohol and water is given, the weight per cent. is found from the equation:

$$a = V \cdot \frac{s}{S}$$

Thus, according to the table (p. 85) spirit containing 68 volumes per cent. of alcohol has a sp. gr. of 0·8949 at 60° F. Hence the weight per cent. of alcohol is:

$$a = 68 \,.\, \frac{7946}{8949} = 60{\cdot}38$$

that is to say: 100 lbs. of this spirit contain 69·38 lbs. of alcohol and 39·62 lbs. of water.

The specific gravity of aqueous alcohol may be determined by any of the ordinary methods; either by weighing in a specific gravity bottle, or by means of the hydrometer (See SPECIFIC GRAVITY and HYDROMETER) and thence the percentage of anhydrous alcohol by weight and by volume may be determined by means of the preceding formulæ and the tables to be given hereafter. To facilitate these determinations, hydrometers are constructed with scales marking directly the percentage of alcohol by volume, and sometimes also by weight, of the spirit in which they are immersed. Such instruments are called ALCOHOLOMETERS. Three of them are in use, viz. the alcoholometer of Tralles, which gives the percentage volume for the temperature of 60° F. = $12\frac{4}{9}$ R. = $15\frac{5}{9}$ C.; Gay-Lussac's alcoholometer, which likewise indicates percentage by volume at 15° C.; and Meissner's, which gives percentages both by weight and volume, the latter for the temperature of 14° R = 17·5° C.

As the scales of these instruments are constructed for different temperatures, they cannot be expected to agree exactly; but the differences arising from this cause are trifling. Greater discrepancies however arise from the different experimental data upon which the scales have been constructed; that of Tralles being founded on the exact and extensive observations of Gilpin, and Meissner's on experiments of his own. Gay-Lussac has not stated on what experimental data his observations are founded, but his numbers agree very nearly with those of Tralles, the differences never exceeding ½ per cent. for the same specific gravity.

The following table gives the percentages of anhydrous alcohol both by weight and volume of mixtures of alcohol and water, according to their specific gravity as determined by Tralles from the observations of Gilpin; also the specific gravities as determined by Gay-Lussac. They are deduced from Tralles' numbers by multiplying by 1·0009. The corresponding indications of the hydrometers of Beck, Baumé, and Cartier, are likewise added.

TABLE II.

Volumes per cent. according to Tralles.	Weights per cent.	Specific gravities according to Gilpin at 60° F.=$15\frac{5}{9}$ C.	Specific gravities according to Gay-Lussac at 15° C.	Degrees of Beck's Hydrometer.	Degrees of Baumé's Hydrometer.	Degrees of Cartier's Hydrometer.
0	0	1·0000	1·0000	0·0	10	11
1	0·80	0·9985	—	—	—	—
2	1·60	9970	—	—	—	—
3	2·40	9956	—	—	—	—
4	3·20	9942	—	1·0	—	—
5	4·00	9928	—	1·2	11	12
6	4·31	9915	—	1·4	—	—
7	5·62	9902	—	1·6	—	—
8	6·43	9890	—	1·9	—	—
9	7·24	9878	—	2·1	—	—
10	8·05	9866	—	2·3	12	—
11	8·87	9854	—	2·5	—	—
12	9·69	9844	—	2·7	—	13
13	10·51	9832	—	2·9	—	—
14	11·33	9821	—	3·1	—	—
15	12·15	9811	—	3·3	—	—
16	12·98	9800	—	3·5	13	—
17	13·80	9790	—	3·6	—	—
18	14·63	9780	—	3·8	—	—
19	15·46	9770	—	4·0	—	14
20	16·28	9760	—	4·2	—	—
21	17·11	9750	—	4·4	—	—
22	17·95	9740	—	4·6	—	—
23	18·78	9729	—	4·8	14	—
24	19·62	9719	—	4·9	—	—
25	20·46	9709	—	5·1	—	—
26	21·30	9698	—	5·3	—	15
27	22·14	9688	—	5·5	—	—
28	22·99	9677	—	5·7	—	—
29	23·84	9666	—	5·9	15	—
30	24·69	9655	0·9656	6·1	—	—
31	25·55	9643	—	6·4	—	—
32	26·41	9631	—	6·6	—	—

TABLE II. (*continued*).

Volumes per cent. according to Tralles.	Weights per cent.	Specific Gravities according to Gilpin at 60° F.=15$\frac{5}{9}$C.	Specific Gravities according to Gay-Lussac at 15° C.	Degrees of Beck's Hydrometer.	Degrees of Baumé's Hydrometer.	Degrees of Cartier's Hydrometer.
33	27·27	0·9618	0·9656	6·8	15	16
34	28·13	9605	—	7·0	16	—
35	28·99	9592	9595	7·2	—	—
36	29·86	9579	—	7·5	—	—
37	30·74	9565	—	7·7	—	—
38	31·62	9550	—	8·0	—	17
39	32·50	9535	—	8·3	17	—
40	33·39	9519	9523	8·6	—	—
41	34·28	9503	—	8·0	—	—
42	35·18	9487	—	9·2	—	18
43	36·08	9470	—	9·5	18	—
44	36·99	9452	—	9·8	—	—
45	37·90	9435	9440	10·2	—	—
46	38·82	9417	—	10·5	19	19
47	39·75	9399	—	10·9	—	—
48	40·66	9381	—	11·2	—	—
49	41·59	9362	—	11·6	—	—
50	42·52	9343	9348	11·9	20	20
51	43·47	9323	—	12·3	—	—
52	44·42	9303	—	12·7	—	—
53	45·36	9283	—	13·1	21	—
54	46·32	9262	—	13·5	—	21
55	47·29	9242	9248	13·9	—	—
56	48·26	9221	—	14·3	22	—
57	49·23	9200	—	14·8	—	22
58	50·21	9178	—	15·2	23	—
59	51·20	9156	—	15·6	—	—
60	52·20	9134	9141	16·1	—	23
61	53·20	9112	—	16·5	24	—
62	54·21	9090	—	17·0	—	—
63	55·21	9067	—	17·5	25	24
64	56·22	9044	—	18·0	—	—
65	57·24	9021	9027	18·4	—	25
66	59·27	8997	—	18·9	26	—
67	59·32	8973	—	19·4	—	—
68	60·38	8949	—	20·0	27	26
69	61·42	8925	—	20·5	—	—
70	62·50	8900	8907	21·0	28	27
71	63·58	8875	—	21·5	—	—
72	64·66	8850	—	22·1	—	—
73	65·74	8824	—	22·6	29	28
74	66·83	8799	—	23·2	—	—
75	67·93	8773	8799	23·8	30	29
76	69·05	8747	—	24·4	—	—
77	70·18	8720	—	25·0	31	30
78	71·31	8693	—	25·6	—	—
79	72·45	8664	—	26·2	32	—
80	73·59	8639	8645	26·8	—	31
81	74·74	8611	—	27·4	33	—
82	75·91	8583	—	28·0	34	32
83	77·09	8555	—	28·7	—	—
84	78·29	8526	—	29·4	35	33
85	79·50	8496	8502	30·1	—	—
86	80·71	8466	—	30·8	36	34

TABLE II. (*continued*).

Volumes per cent. according to Tralles.	Weights per cent.	Specific Gravities according to Gilpin at 60°=$15\frac{5}{9}$° C.	Specific Gravities according to Gay-Lussac at 15° C.	Degrees of Beck's Hydrometer	Degrees of Baumé's Hydrometer.	Degrees of Cartier's Hydrometer.
87	81·94	0·8436	0·8502	31·5	37	35
88	83·19	8405	—	32·2	—	—
89	84·46	8373	—	33·0	38	36
90	85·75	8340	8346	33·8	—	—
91	87·09	8306	—	34·7	39	37
92	88·37	8272	—	35·5	40	38
93	89·71	8237	—	36·4	41	—
94	91·07	8201	—	37·3	—	39
95	92·46	8164	8168	38·2	42	40
96	93·89	8125	—	39·2	43	—
97	95·34	8084	—	40·3	44	41
98	96·84	8041	—	41·5	45	42
99	98·39	7995	—	42·7	46	43
100	100·00	7946	7947	43·9	47	—

The use of this table may be extended to intermediate numbers by interpolation. Thus, if it be required to find the composition by volume of a mixture of 50 lbs. of anhydrous alcohol and 50 lbs. of water, we find from the table that:

49·23 p. c. by weight corresponds to 57 p. c. by volume
and: 50·2 " " 58 "
difference 0·98 and . 1

Hence, to find the fraction which must be added to the number 57 to give the percentage required, we have the proportion:

$$0·98 : (50 - 49·23) = 1 : x$$

which gives: $x = \frac{77}{98} = 0·8$

Whence it appears that 100 volumes (measured at 60° F.) of a spirit containing equal weights of alcohol and water contain 57·8 volumes of alcohol, also at 60°.

Again, let it be required to find the composition of a spirit having at 60° Fahr. the specific gravity 0·8955, compared with water at the same temperature; this number is intermediate between the numbers 8949 and 8973 in the third column of the table, which correspond to the volume per centages 67 and 68; hence the proportion:

$$8973 - 8949 : 8973 - 8955 = 1 : x$$

which gives $x = \frac{18}{24} = \frac{3}{4}$

that is to say, 100 measures of spirit of sp. 0·8955 at 60° Fahr. contain 67¾ measures of anhydrous alcohol.

Meissner's results are given in his "Aräometrie in ihrer Anwendung auf Chemie und Technik," Wien, 1816. Th. ii. 27. They differ somewhat from the preceding.

TABLE II. *a.—Specific Gravity* (*according to Meissner*) *of Hydrated Alcohol containing in* 100 *parts:*

Alcohol.	By Weight.		By Volume.	
Parts.	At 20° C.	At 17·5° C.	At 20° C.	At 17·5° C.
100	0·791	0·793	0·791	0·793
95	0·805	0·801	0·809	0·811
90	0·818	0·822	0·824	0·828
85	0·831	0·835	0·839	0·843
80	0·843	0·847	0·854	0·857
75	0·856	0·859	0·867	0·869
70	0·868	0·870	0·880	0·883

TABLE II. *a.* (*continued*).

Alcohol.	By Weight.		By Volume.	
Parts.	At 20° C.	At 17·5° C.	At 20° C.	At 17·5° C.
65	0·880	0·883	0·893	0·896
60	0·892	0·895	0·906	0·907
55	0 904	0·906	0·917	0·919
50	0·915	0·917	0·928	0·930
45	0·926	0·928	0·938	0·940
40	0·937	0·939	0·947	0·949
35	0·947	0·948	0·955	0·958
30	0·955	0·958	0·963	0·964
25	0·963	0·965	0·969	0·970
20	0·970	0·971	0·975	0·976
15	0·977	0·977	0·981	0·980
10	0·984	0·983	0·987	0·986
5	0·992	0·991	0·993	0·993
0	1·000	1·000	1·000	1·000

TABLE II. *b.*—*The following Table is given by Fownes* (Manual of Chemistry, 3rd Ed. p. 591), *the Specific Gravities being taken at* 15·6° C. *or* 60 Fahr.

Percentage by weight.	Specific Gravity.	Percentage by weight.	Specific Gravity.	Percentage by weight.	Specific Gravity.
0·5	0·9991	34	0·9511	68	0·8769
1	0·9981	35	0·9490	69	0·8745
2	0·9965	36	0·9470	70	0·8721
3	0·9947	37	0·9452	71	0·8696
4	0·9930	38	0·9434	72	0·8672
5	0·9914	39	0·9416	73	0·8649
6	0·9898	40	0·9396	74	0·8625
7	0·9884	41	0·9376	75	0·8603
8	0·9869	42	0·9356	76	0·8581
9	0·9855	43	0·9335	77	0·8557
10	0·9841	44	0·9314	78	0·8533
11	0·9828	45	0·9292	79	0·8508
12	0·9815	46	0·9270	80	0·8483
13	0·9802	47	0·9249	81	0·8459
14	0·9789	48	0·9228	82	0·8434
15	0·9778	49	0·9206	83	0·8408
16	0·9766	50	0·9184	84	0·8382
17	0·9753	51	0·9160	85	0·8357
18	0·9741	52	0·9135	86	0·8331
19	0·9728	53	0·9113	87	0·8305
20	0·9716	54	0·9090	88	0·8279
21	0·9704	55	0·9069	89	0·8254
22	0·9691	56	0·9047	90	0·8228
23	0·9678	57	0·9025	91	0·8199
24	0·9665	58	0·9001	92	0·8172
25	0·9652	59	0·8979	93	0·8145
26	0·9638	60	0·8956	94	0·8118
27	0·9623	61	0·8932	95	0·8089
28	0·9609	62	0·8908	96	0·8061
29	0·9593	63	0·8886	97	0·8031
30	0·9578	64	0·8863	98	0·8001
31	0·9560	65	0·8840	99	0·7969
32	0·9544	66	0·8816	100	0·7938
33	0·9528	67	0·8793		

It is often necessary to take the specific gravity of spirit at a temperature different from the standard. In that case, the percentage of alcohol may be determined by means of the two following tables, given by Tralles.

Table III. — *Specific Gravity of Spirit of different strengths at Temperatures from* 30° *Fahr. to* 100° *Fahr. that of Water at* 39·83 *Fahr. being* = 10000.

Quantity of Alcohol at 60° Fahr. in percentages by. Volume.	Temperatures (Fahr.)														
	30°.	35°.	40°.	45°.	50°.	55°.	60°.	65°.	70°.	75°.	80°.	85°.	90°.	95°.	100°.
0	9998	10000	10000	10000	9998	9995	9991	9986	9980	9974	9967	9959	9951	9941	9931
5	9928	9929	9929	9928	9926	9923	9919	9914	9908	9901	9894	9816	9877	9864	9857
10	9872	9872	9871	9869	9866	9862	9857	9851	9844	9837	9828	9820	9810	9800	9789
15	9827	9825	9823	9819	9814	9808	9802	9795	9787	9777	9768	9758	9747	9735	9723
20	9790	9786	9780	9774	9767	9759	9751	9742	9732	9721	9710	9698	9685	9672	9658
25	9756	9748	9739	9731	9721	9710	9700	9689	9676	9664	9650	9637	9622	9607	9591
30	9719	9708	9697	9685	9672	9659	9646	9632	9618	9603	9587	9571	9555	9538	9521
35	9672	9658	9644	9629	9614	9599	9583	9566	9550	9532	9515	9497	9479	9461	9442
40	9613	9597	9580	9562	9543	9528	9510	9492	9473	9454	9435	9416	9396	9376	9356
45	9539	9521	9503	9484	9466	9446	9427	9407	9387	9367	9347	9326	9305	9284	9263
50	9453	9454	9415	9395	9375	9355	9335	9314	9293	9272	9251	9229	9207	9185	9162
55	9358	9338	9318	9297	9276	9255	9234	9212	9191	9169	9147	9125	9102	9079	9056
60	9253	9233	9212	9191	9169	9148	9126	9104	9082	9059	9036	9013	8990	8967	8943
65	9148	9122	9101	9080	9058	9035	9013	8991	8968	8945	8921	8898	8875	8851	8826
70	9025	9004	8982	8960	8937	8914	8892	8869	8846	8823	8799	8775	8751	8727	8702
75	8900	8878	8856	8833	8811	8789	8765	8742	8719	8695	8671	8646	8622	8598	8573
80	8768	8746	8723	8701	8678	8654	8631	8608	8584	8560	8535	8511	8487	8462	8437
85	8627	8604	8581	8558	8535	8511	8488	8464	8440	8416	8392	8367	8343	8318	8293
90	8472	8449	8426	8426	8380	8356	8332	8308	8284	8260	8235	8211	8186	8161	8136

Table IV.—*Volumes of Alcohol of Specific Gravity* 7939 *at* 60° *Fahr. which would be contained at* 60° *Fahr. in* 100 *measures of Spirit exhibiting at the several Temperatures (Fahr.) stated at the heads of the columns the following apparent Specific Gravities as determined with a Glass vessel or instrument.*

Volumes of Alcohol.	30°.	35°.	40°.	45°.	50°.	55°.	60°.	65°.	70°.	75°.	80°.	85°.
0	9994	9997	9997	9998	9997	9994	9991	9987	9981	9976	9970	9962
5	9924	9926	9929	9926	9925	9922	9919	9915	9909	9903	9897	9889
10	9868	9869	9868	9867	9865	9861	9857	9852	9845	9839	9831	9823
15	9823	9822	9820	9817	9813	9807	9802	9796	9788	9779	9771	9761
20	9786	9782	9777	9772	9766	9759	9751	9743	9735	9723	9713	9701
25	9752	9745	9737	9729	9720	9709	9700	9690	9678	9666	9653	9640
30	9715	9705	9694	9683	9671	9658	9646	9633	9619	9606	9590	9574
35	9668	9655	9641	9627	9612	9598	9583	9567	9551	9535	9518	9500
40	9609	9594	9577	9560	9544	9527	9510	9493	9474	9456	9438	9419
45	9535	9518	9500	9482	9464	9445	9427	9408	9388	9369	9350	9329
50	9449	9431	9413	9393	9374	9354	9335	9315	9294	9274	9253	9232
55	9354	9335	9316	9295	9275	9254	9234	9213	9192	9171	9150	9128
60	9249	9230	9210	9189	9168	9147	9126	9105	9083	9061	9039	9016
65	9140	9120	9099	9078	9056	9034	9013	8992	8969	8947	8924	8901
70	9021	9001	8980	8958	8936	8913	8892	8870	8847	8825	8801	8778
75	8896	8875	8854	8832	8810	8787	8765	8742	8720	8697	8673	8649
80	8764	8743	8721	8699	8676	8653	8631	8609	8585	8562	8538	8514
85	8623	8601	8579	8556	8533	8510	8488	8465	8441	8468	8394	8370
90	8469	8446	8423	8401	8379	8355	8332	8309	8285	8262	8238	8214

Reductions for a *Brass* Instrument.

To be deducted from the Specific Gravities.						To be added to the Specific Gravities.					
−5	−4	−3	−2	−2	−1	0	+1	+2	+2	+3	+4

In Table III. the specific gravity of the spirit is supposed to be compared with that of water at the maximum density, and to be corrected for the expansion of the vessel or instrument with which the determination is made. These densities may be reduced to those compared with water at 60° F. (as in Table II.), by multiplying them all by 1·0009.

To find by means of this table the strength of a spirit, when either the specific gravity or the temperature is not given exactly as in the tables, we proceed by interpolation as in the calculations connected with Table II. (p. 85.) But if neither temperature nor specific gravity is exactly given in the table, the calculation is made as in the following example. Let it be required to find the strength of a spirit of sp. gr. 0·9321 at 77° F.

	Specific Gravity		
Per cent. of Alcohol.	at 75° F.	at 80° F.	Difference.
45	9367	9347	20
50	9272	9251	21
Difference 5	95	96	

Hence the sp. gr. for 77° F., and for:

$$45 \text{ p. c. alcohol is } 9367 - 2 \times \frac{20}{5} = 9359$$

$$50 \quad ,, \quad 9272 - 2 \times \frac{21}{5} = 9263{\cdot}6$$

$$\text{Difference} = \overline{95{\cdot}4}$$

Calling this difference 95, it follows that to each 1 per cent. of alcohol there corresponds at 77° F. a difference of 19 in the specific gravity, and consequently the volume per cent. of alcohol corresponding to the specific gravity 9321 is

$$45 + \frac{9359 - 9321}{19} = 45 + \frac{38}{19} = 47 \text{ vol. p. c.}$$

This result shows that the spirit in question, when cooled down to the normal temperature of 60° F. contains in 100 measures, 47 measures of absolute alcohol; this is not, however, the actual proportion by volume at 77°, because alcohol and water expand at different rates.

Table IV. exhibits in the same manner as Table III. the strength of spirit according to its specific gravity, but on the supposition that the specific gravity is determined with a glass instrument, and is not corrected for the expansion of the glass: hence the expression "apparent specific gravity."

If the specific gravity of a sample of spirit has been determined at one temperature and its volume measured at another, the amount of alcohol in it may be calculated as in the following example: 350 quarts of spirit are measured out at 75° F., and the specific gravity determined with a glass instrument at 65° F. is 0·8609. By Table IV. the strength of this spirit is 80 per cent., that is to say, 100 volumes of it measured at 60° F. contain 80 vol. of alcohol. By Table III. the specific gravities of spirit of 80° per cent. for the temperatures 60° and 75° are 8631 and 8560. Consequently the volumes of a given weight of the spirit at 60° and 75° are as 8560 : 8631, and therefore the 350 quarts of spirit would, if cooled to 60°, measure $350 \times \frac{8560}{8631} = 347{\cdot}12$ quarts; and this volume of liquid at the strength of 80 per cent. contains 277·7 quarts of real alcohol.

To ensure perfect accuracy, the expansion of the vessel in which the spirit is measured ought to be taken into account; but for commercial purposes, to which calculations of this kind chiefly apply, this correction is too small to be of any importance.

The quantity of alcohol of 60° F. in 100 volumes of spirit of the same temperature is called the *strength* (*Stärke; force*), of the spirit; and the quantity of alcohol of 60° F. in 100 volumes of spirit of any given temperature is called the *real amount of alcohol* (*wahrer Alkoholgehalt; richesse*). Thus in the example just given, the strength of the spirit is 80. but the real amount of alcohol is $\frac{277{\cdot}7}{350} \times 100 = 79{\cdot}3$.

The following Tables, V. and VI., exhibit the *strength* and the *real amount of alcohol* of a sample of spirit, according to the indications of the alcoholometer and the thermometer. If, for example, the alcoholometer marks 75 per cent. in a spirit whose temperature is 50° F., we find from line 16, column 6, of Table V. that the strength of the spirit is 76·7, and from the corresponding place in Table VI that its real amount of alcohol is 77·1 per cent.

Table V. — *Showing the Amount of Alcohol which a given sample of Spirit would contain at 60° F. according to the indication of a glass Alcoholometer, immersed in it at any other temperature.*

Indications of the Alcoholometer.	Strength of the Spirit, when tested by the Alcoholometer at the following temperatures.												
	0° 0 32	2° 2·5 36·5	4° 5 41	6° 7·5 45·5	8° 10 50	10° 12·5 54·5	12° 15 59	14° 17·5 63·5	16° 20 68	18° 22·5 72·5	20° 25 77	22° 27·5 81·5	24 R. 30 C. 86 F.
0	0·3	0·4	0·4	0·4	0·4	0·2	0	—	—	—	—	—	—
5	5·4	5·5	5·5	5·5	5·4	5·2	5·0	4·7	4·4	4·1	3·7	3·2	2·5
10	11·2	11·1	11·0	10·9	10·7	10·4	10·1	9·7	9·2	8·8	8·3	7·8	7·3
15	17·8	17·4	17·0	16·5	16·0	15·6	15·1	14·6	14·0	13·4	12·8	12·2	11·6
20	24·7	23·9	23·1	22·3	21·7	20·9	20·2	19·5	18·8	18·0	17·2	16·5	15·7
25	31·2	30·1	28·9	28·0	27·1	26·1	25·2	24·4	23·5	22·5	21·6	20·7	19·8
30	36·5	35·4	34·3	33·3	32·3	31·3	30·2	29·2	29·3	27·3	26·3	25·3	24·3
35	41·4	40·4	39·3	38·3	37·3	36·2	35·2	34·2	33·2	32·2	31·2	30·2	29·1
40	46·1	45·1	44·1	43·1	42·1	41·2	40·2	39·2	38·2	37·2	36·2	35·2	34·3
45	50·8	50·0	49·0	48·1	47·1	46·2	45·2	44·2	43·2	42·3	41·3	40·4	39·4
50	55·6	54·7	53·9	53·0	52·0	51·1	50·2	49·3	48·4	47·4	46·5	45·6	44·6
55	60·4	59·5	58·7	57·8	56·9	56·1	55·2	54·4	53·5	52·6	51·6	50·7	49·7
60	65·2	64·4	63·6	62·7	61·9	61·1	60·2	59·4	58·5	57·6	56·7	55·8	54·9
65	70·0	69·3	68·5	67·7	66·9	66·1	65·2	64·4	63·5	62·7	61·8	60·9	59·9
70	74·8	74·1	73·4	72·6	71·8	71·0	70·2	69·4	68·6	67·8	66·9	66·1	65·2
75	79·7	79·0	78·2	77·4	76·7	75·9	75·2	74·4	73·7	72·8	72·0	71·2	70·3
80	84·4	83·7	83·0	82·3	81·6	80·9	80·2	79·4	78·7	77·9	77·2	76·4	75·6
85	89·1	88·5	87·8	87·2	86·5	85·8	85·1	84·5	83·7	83·0	82·3	81·5	80·8
90	93·7	93·2	92·6	92·0	91·4	90·8	90·1	89·5	88·8	88·2	87·5	86·8	86·1
95	98·2	97·7	97·1	96·7	96·1	95·6	95·1	94·6	94·0	93·4	92·8	92·8	91·6
100	—	—	—	—	—	—	100·1	99·6	99·1	98·5	98·0	97·5	97·2

Table VI. — *Showing the Real Amount of Alcohol in Spirit at different Temperatures according to the indications of a glass Alcoholometer.*

Indications of the Alcoholometer.	Real Amount of Alcohol at the following Temperatures.												
	0° 0 32	2° 2·5 36·5	4° 5 41	6° 7·5 45·5	8° 10 50	10° 12·5 54·5	12° 15 59	14° 17·5 63·5	16° 20 68	18° 22·5 72·5	20° 25 77	22° 27·5 81·5	24° R. 30 C. 86 F.
0	0·3	0·4	0·4	0·4	0·4	0·2	—	—	—	—	—	—	—
5	5·4	5·5	5·5	5·5	5·4	5·2	5·0	4·7	4·4	4·1	3·7	3·2	2·5
10	11·1	11·1	11·0	10·9	10·7	10·4	10·1	9·7	9·2	8·7	8·3	7·8	7·3
15	17·7	17·4	17·1	16·4	16·0	15·5	15·1	14·5	14·0	13·4	12·8	12·2	11·5
20	24·9	24·0	23·1	22·4	21·7	21·0	20·2	19·5	18·8	18·0	17·2	16·4	15·6
25	31·3	30·2	29·2	28·2	27·2	26·2	25·2	24·3	23·4	22·5	21·6	20·7	19·8
30	37·0	35·7	34·6	33·4	32·4	31·3	30·2	29·2	28·2	27·2	26·2	25·2	24·2
35	42·0	40·7	39·6	38·5	37·4	36·2	35·2	34·1	33·1	32·1	31·0	30·0	28·9
40	46·6	45·5	44·5	43·4	42·3	41·2	40·2	39·1	38·0	37·0	36·0	35·0	33·9
45	51·5	50·4	49·4	48·3	47·3	46·2	45·2	44·2	43·1	42·1	41·1	40·0	39·0
50	56·3	55·3	54·3	53·3	52·3	51·2	50·2	49·2	48·2	47·1	46·1	45·0	44·0
55	61·2	60·2	59·2	58·2	57·2	56·2	55·2	54·2	53·2	52·2	51·2	50·2	49·2
60	66·2	65·2	64·2	63·2	62·2	61·2	60·2	59·2	58·2	57·2	56·3	55·3	54·3
65	71·1	70·1	69·1	68·1	67·2	66·2	65·2	64·2	63·3	62·3	61·3	60·3	59·3
70	76·0	75·0	74·1	73·1	72·1	71·1	70·2	69·3	68·3	67·3	66·4	65·4	64·4
75	80·9	79·9	79·0	78·1	77·1	76·1	75·2	74·3	73·3	72·3	71·4	70·4	69·4
80	85·7	84·9	83·9	83·0	82·0	81·1	80·2	79·3	78·3	77·4	76·4	75·5	74·5
85	90·5	89·6	88·8	87·9	87·0	86·1	85·2	84·3	83·4	82·4	81·5	80·6	79·6
90	95·0	94·1	93·5	92·7	91·9	91·0	90·2	89·3	88·4	87·5	86·8	85·7	84·8
95	99·5	98·6	98·0	97·4	96·5	95·8	95·2	94·3	93·5	92·7	91·9	91·1	90·2
100	—	—	—	—	—	100·8	100·2	99·6	99·0	98·3	97·6	96·9	95·7

The scale of Tralles' alcoholometer is constructed as follows. Suppose the cylindrical or prismatic stem of the instrument to be divided into a number of equal parts, of arbitrary length; and let v be the volume of that portion of the neck between two consecutive divisions; V the volume of liquid of sp. gr. 1, displaced by the alcoholometer, and P the weight of the alcoholometer; then

$$P = V \, . \, 1.$$

If now the division to which the instrument sinks in this liquid be marked 0, the divisions being numbered upwards therefrom, and if the instrument be immersed in spirit of specific gravity s to the mark n, we have

$$P = (V + n\,v)\,s,$$

which equations give,

$$V = (V + nv)\,s, \text{ or } n = \frac{V}{v}\left(\frac{1}{s} - 1\right) = \frac{V}{v} \cdot \frac{1-s}{s}$$

The arbitrary quantity v is fixed by Tralles at such a magnitude that

$$n = 10000 \cdot \frac{1-s}{s}$$

Now for 60° F. the specific gravity of water compared with that of water at its maximum density (Table I.) is 0·9991: hence for the division in which the instrument sinks in pure water at 60°, we find,

$$n = 10000 \cdot \frac{1-0{\cdot}9991}{0{\cdot}9991} = 9.$$

Again, spirit of 80 per cent. has at 60° F. the sp. gr. 0·8631: hence, for the division to which the instrument sinks therein, we have

$$n = 10000 \cdot \frac{1-0{\cdot}8631}{0{\cdot}8631} = 1587,$$

and in like manner the values of the other divisions of the scale may be found: they are given in Table VII.

To graduate an alcoholometer by means of this table, the instrument is first immersed in pure water at 60° F., and the point of the stem to which it sinks is marked 9. It is next immersed in spirit of known strength, and the point marked to which it sinks when the liquid is at 60° F. Thus if spirit of 90 per cent. be used, the number of the division will be

$$n = 10000 \cdot \frac{1-0{\cdot}8340}{0{\cdot}8340} = 2002.$$

The interval between these two marks is then to be divided into $2002-9 = 1993$ equal parts, and the divisions continued upwards as far as 2597, which corresponds to absolute alcohol. The percentages in the first column of Table VII. are then marked on the scale by the side of the numbers of the divisions in the second column.

To verify the scale of an alcoholometer already divided, the specific gravities of a number of samples of spirit varying in strength by nearly equal intervals between 0 and 100 per cent. may be determined by any of the ordinary methods; the corresponding strength found from Tables I., II., or III.; the temperatures of them all then reduced to 60° F.; and the alcoholometer immersed in them in order to ascertain whether its indications agree with the strengths so determined. The intermediate points may be tested by comparison with the numbers in the columns of Table VII marked "Differences."

TABLE VII.—*Alcoholometer-scale for Volumes per Cent. at 60° F.*

Amount of Alcohol by Volume.	Length of immersed part of Stem.	Differences.	Amount of Alcohol by Volume.	Length of immersed part of Stem.	Differences.	Amount of Alcohol by Volume.	Length of immersed part of Stem.	Differences.
0	9		22	277	11	44	588	19
1	24	15	23	288	11	45	608	20
2	39	15	24	299	11	46	628	20
3	54	15	25	310	11	47	648	20
4	68	14	26	321	11	48	669	21
5	82	14	27	332	11	49	690	21
6	95	13	28	344	12	50	712	22
7	108	13	29	355	11	51	735	23
8	121	13	30	367	12	52	758	23
9	133	12	31	380	13	53	782	24
10	145	12	32	393	13	54	806	24
11	157	12	33	407	14	55	830	24
12	169	12	34	420	13	56	854	24
13	180	11	35	434	14	57	879	25
14	191	11	36	449	15	58	905	26
15	202	11	37	465	16	59	931	26
16	213	11	38	481	16	60	957	26
17	224	11	39	498	17	61	984	27
18	235	11	40	515	17	62	1011	27
19	245	10	41	533	18	63	1039	28
20	256	10	42	551	18	64	1067	28
21	266	10	43	569	18	65	1096	29

TABLE VII—(*continued*).

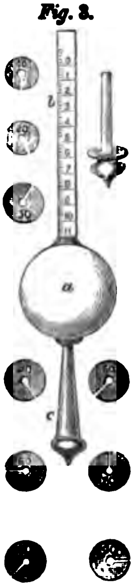
Amount of Alcohol by Volume.	Length of immersed part of Stem.	Differences.	Amount of Alcohol by Volume.	Length of immersed part of Stem.	Differences.	Amount of Alcohol by Volume.	Length of immersed part of Stem.	Differences.
66	1125	29	78	1514	36	90	2002	47
67	1154	29	79	1550	36	91	2050	48
68	1184	30	80	1587	37	92	2099	49
69	1215	31	81	1624	37	93	2150	51
70	1246	31	82	1662	38	94	2203	53
71	1278	32	83	1701	39	95	2259	56
72	1310	32	84	1740	39	96	2318	59
73	1342	32	85	1781	41	97	2380	62
74	1375	33	86	1823	42	98	2447	67
75	1409	34	87	1866	43	99	2519	72
76	1443	34	88	1910	44	100	2597	78
77	1478	35	89	1955	45			

The following is a similar table for percentages by weight.

TABLE VIII.—*Alcoholometer-scale for Weights per Cent. at* 60° *F.*

Amount of Alcohol by Weight.	Length of immersed part of Stem.	Differences.	Amount of Alcohol by Weight.	Length of immersed part of Stem.	Differences.	Amount of Alcohol by Weight.	Length of immersed part of Stem.	Differences.
0	9	—						
1	28	19	35	547	20	68	1411	31
2	46	18	36	568	21	69	1442	31
3	64	18	37	589	21	70	1473	31
4	82	18	38	610	21	71	1505	32
5	98	16	39	633	22	72	1536	31
6	114	16	40	655	22	73	1568	32
7	130	16	41	677	22	74	1600	32
8	145	15	42	700	23	75	1632	32
9	159	14	43	724	24	76	1664	32
10	173	14	44	748	24	77	1697	33
11	187	14	45	772	24	78	1730	33
12	201	14	46	797	25	79	1763	33
13	214	13	47	822	25	80	1796	33
14	227	13	48	847	25	81	1830	34
15	240	13	49	873	26	82	1865	35
16	252	12	50	899	26	83	1901	36
17	264	12	51	925	26	84	1938	37
18	277	13	52	951	26	85	1975	37
19	291	14	53	978	27	86	2012	37
20	304	13	54	1005	27	87	2050	38
21	317	13	55	1033	28	88	2088	38
22	330	13	56	1061	28	89	2126	38
23	343	13	57	1089	28	90	2165	39
24	357	14	58	1117	28	91	2204	39
25	371	14	59	1145	28	92	2254	40
26	386	15	60	1173	28	93	2286	42
27	402	16	61	1202	29	94	2329	43
28	419	17	62	1231	29	95	2372	43
29	435	16	63	1261	30	96	2415	43
30	452	17	64	1290	29	97	2458	43
31	469	17	65	1320	30	98	2503	45
32	487	18	66	1350	30	99	2549	46
33	507	20	67	1380	30	100	2597	48
34	527	20						

Fig. 2.



Various other hydrometers or areometers are also used for taking the specific gravity and ascertaining the strength of spirits. Sikes's hydrometer is the one used in levying the spirit duty in this country. This instrument has a four-sided stem *b*, divided into 11 equal parts, and fitting into a brass ball *a*, which carries at the bottom a small conical stem *c*, terminating in a pear-shaped loaded bulb. It is also provided with 9 circular weights, numbered 10, 20, 30, 40, 50, 60, 70, 80, 90, having slits by which they fit into the stem. The instrument is adjusted so as to float with the zero of the scale coinciding with the surface of the liquid in spirit of specific gravity 0·825 at 60°F. which is the "*standard alcohol*" of the excise (p. 82). In weaker spirit it will not sink so low; and if the density of the liquid be much greater, it will be necessary to add one or more of the weights, to cause the entire immersion of the bulb. The sum of the numbers of the weights together with the number on the scale which is at the level of the liquid, gives, by means of a table provided for the purpose, the amount of *proof spirit* in the sample, proof spirit being, according to Act of Parliament, such as at 51° Fahr. weighs $\frac{12}{13}$ as much as an equal bulk of water, or in other words has a specific gravity of 0·923077 at 51°, or 0·919 at 60° F.

When spirit is said to be 30 per cent. (for example) *above proof*, the meaning is, that 100 measures of this spirit, when diluted with water, would yield 130 measures of proof spirit; on the other hand, spirit 30 per cent. *below proof* contains in 100 measures, 100 − 30 or 70 measures of proof spirit.

It is often required to find the quantity of water which must be added to spirit containing a given percentage of alcohol in order to reduce it to a lower percentage. If the actual and required amounts are given in weights per cent., *a* and *a′*, the weight *x* of water to be added to 100 lbs of spirit to reduce the percentage of alcohol from *a* to *a′*, is given by the proportion:

$$100 + x : a = 100 : a',$$

$$\text{whence } x = 100\left(\frac{a}{a'} - 1\right)$$

If, for example, spirit containing 90 lbs. of alcohol in 100 lbs. is to be reduced to spirit containing 60 lbs. per cent., the quantity of water required is

$$100\left(\frac{90}{60} - 1\right) = 100 \times 0{\cdot}5 = 50 \text{ lbs.}$$

Next, let it be required to find what volume of water must be added to 100 volumes of spirit containing *v* volumes per cent. of alcohol to reduce it to *v′* volumes per cent.

If *P* be the weight, and *S* the specific gravity of the spirit we have:

$$P = 100\,S.$$

and if to this we add *w* volumes of water, the weight of which will also be *w* (its specific gravity being 1), we obtain a volume *V* of spirit, whose specific gravity may be denoted by *S′*, and its amount of alcohol in volumes per cent. by *v′*. Then,

$$P + w = 100\,S + w = VS',$$

$$\text{and} \qquad V : 100 = v : v',$$

$$\text{or,} \qquad V = 100 \cdot \frac{v}{v'},$$

because the diluted spirit still contains the *v* volumes of alcohol which were present in the liquid before dilution. From these two equations we find

$$w = 100\left(\frac{v}{v'}\,S' - S\right)$$

For example, to reduce spirit of 80 volumes p. c. to spirit of 40 volumes p. c. we find,

$$w = 100 \cdot \left(\frac{80}{40} \cdot 0{\cdot}9519 - 0{\cdot}8639\right) = 103{\cdot}99$$

so that 100 measures of the given spirit require 103·99 measures of water at 60°F. to reduce them from 80 to 40 per cent.

The volume of diluted spirit produced by the mixture is

$$v = 100 \frac{v}{v'}$$

In the example just given, $100 \cdot \frac{80}{40} = 200$ volumes, less therefore than the sum of the volumes of the liquids mixed.

On the principles just explained, the numbers in the following table are calculated. It must be observed, however, that the specific gravities are given as determined by Gay-Lussac, and correspond to 15° C. on which account the result of the calculation just given does not agree exactly with the number in the table.

The original volumes per cent. of the spirit are placed at the tops of the columns, and the percentages to which they are to be reduced in the first column of the table. Thus to find how much water is required to reduce spirit of 75 per cent. to 40 per cent. look in the column headed 70 for the number on a level with 40 in the first column, we thus find that 77·58 volumes is the quantity of water required:

TABLE IX.—*Showing the quantity of Water required to reduce* 100 *volumes of a stronger Spirit to a Spirit of lower strength.*

	90	85	80	75	70	65	60	55	50
85	6·56								
80	13·79	6·83							
75	21·89	14·48	7·20						
70	31·05	23·14	15·35	7·64					
65	41·53	33·03	24·66	16·37	8·15				
60	53·65	44·48	35·44	26·47	17·58	8·76			
55	67·87	57·90	48·07	38·32	28·63	19·02	9·47		
50	84·71	73·90	63·04	52·43	41·73	31·25	20·47	10·35	
45	105·34	93·30	81·38	69·54	57·78	46·09	34·46	22·90	11·41
40	130·80	117·34	104·01	90·76	77·58	64·48	51·43	38·46	25·55
35	163·28	148·01	132·88	117·82	102·84	87·93	73·08	58·31	43·59
30	206·22	188·57	171·05	103·53	136·04	118·94	101·71	84·54	67·45
25	266·12	245·15	224·30	253·61	182·83	162·21	141·65	121·16	100·73
20	355·80	329·84	304·01	278·26	252·58	226·98	201·43	175·96	150·55
15	505·27	471·00	436·85	402·81	368·83	334·91	301·07	267·29	233·64
10	804·54	753·65	702·89	651·21	601·60	551·06	500·59	450·19	399·85

A similar but much more extended table for this purpose is given by Gay-Lussac. (See Haudworterbuch d. Chem. i. 504.)

To determine what quantity of a weaker spirit must be added to a stronger one to produce a spirit of given mean percentage, we proceed as follows.

Let v be the volume of alcohol in 100 measures of the stronger spirit, S its specific gravity, and P its weight. Also let V_1 be the volume of the weaker spirit added, v_1 its percentage of alcohol, S_1 its specific gravity, and P_1 its weight; and lastly, let V_2 be the volume of spirit resulting from the mixture, v_2 its percentage of alcohol, S_2 its specific gravity, and P_2 its weight. Then:

$$P = 100\,S \;:\; P_1 = V_1 S_1 \;:\; P_2 = P + P_1$$

$$\text{or } 100\,S + V_1 S_1 = V_2 S_2 \quad . \quad . \quad . \quad (1).$$

The quantity of alcohol contained in this mixture is,

$$v + \frac{V_1}{100} v_1$$

But since the mixed spirit is to contain V_2 volumes per cent. of alcohol, this quantity of alcohol is also represented by

$$\frac{V_2}{100} v_2$$

Hence the equation:

$$V_2 v_2 = 100\,v + V_1 v_1 . \quad . \quad . \quad (2).$$

And eliminating V_2 between the equations (1) and (2), we have,

$$\frac{100\,S + V_1 S_1}{S_2} v_2 = 100\,v + V_1 v_1$$

whence we obtain:

$$V = \frac{100 \frac{v}{v_2} S - 100 S}{S_1 - \frac{v_1}{v_2} S_2}.$$

The numerator of this fraction is the quantity of water which must be added to 100 volumes of the stronger spirit to produce a spirit of the required strength. The denominator may be written in the form,

$$\frac{v_1}{v_2}\left(\frac{v_2}{v_1} S_1 - S_2\right)$$

and is therefore the volume of water which must be added to $\frac{v_1}{v_2}$ volumes of spirit containing v_2 per cent. of alcohol to bring it to the percentage v_1.

To determine the amount of alcohol in spirituous liquors, such as wine or beer, containing foreign matters, as volatile oils, sugar, mucilage, saline substances, &c., the liquid may be distilled, and the distillate, which will be free from the fixed impurities, may be treated by the methods already described. Volatile oils are for the most part of nearly the same specific gravity as alcohol, and the small quantities of them existing in vinous liquors do not make any essential difference in the specific gravity.

Other physical characters have also been resorted to for determining the strength of spirituous liquors, viz. the boiling-point, vapour-density, rate of expansion, &c.

The *boiling-point* of hydrated alcohol has been proposed by Gröning as a means of determining its strength. For this purpose, he has constructed the following table.

Per Cent. of Alcohol.	Boiling-Point.	Per Cent. of Alcohol.	Boiling-Point.	Per Cent. of Alcohol.	Boiling-Point.
5	96·3 C.	40	84·1 C.	70	80·9 C.
10	92·9	45	83·4	75	80·3
15	91·0	50	83·1	80	79·7
20	89·1	50	82·2	85	79·4
25	87·5	60	81·9	90	79·0
30	86·2	65	81·5	95	78·4
35	85·0				

According to Dalton, alcohol of 43 per cent. boils at 84° C.

J. J. Pohl (Denkschriften d. math. naturw. Classe d. Wien. Akad. II. abstr. Wien, Akad. Ber. 1850; Marz. 246; Jahresber. 1850, 455) has also determined the boiling-point of hydrated alcohol of various strengths. He finds that, at the commencement of the ebullition, the thermometer remains constant for a short time, then slowly rises a little, and afterwards remains constant for a somewhat longer time (from 4 to 16 seconds when 14·6 grms. of liquid were used). The temperatures at the second stationary interval are given in the following table (Bar. at 760 mm.)

Percentage of Alcohol.	Boiling-Point.	Percentage of Alcohol.	Boiling-Point.
0	100·00° C.	7	93·43° C.
1	98·79	8	92·70
2	97·82	9	92·03
3	96·85	10	91·40
4	95·90	11	90·83
5	95·02	12	90·27
6	94·21		

The presence of sugar in the liquid up to 15 p. c. appears not to exert any perceptible influence on the boiling-point (a mixture of 10 pts. alcohol with 15 sugar and 75 water boiled at the same temperature as a mixture of 10 alcohol and 90 water).

Instruments, called *Ebullioscopes*, for directly ascertaining the strength of hydrated alcohol by its boiling-point, have been constructed by Broissard-Vidal and by Conaty. (See a report on these instruments by Despretz, Pouillet, and Babinet, Compt. rend. xxvii. 374. A description and figure of a Vidal-instrument are given in the Pharm. J. Trans. vii. 166.) Ure (Pharm. J. Trans. vii. 166; Pharm. Centr. 1847, 422) by means of an instrument similar to Conaty's (which is merely an ordinary thermometer, having a moveable scale which can be shifted so as to correspond with the variations of the barometer, and has the percentages of alcohol marked on it) has determined the boiling-points of hydrated alcohol as follows:

Specific Gravity.	Boiling-Point.	Specific Gravity.	Boiling-Point.
0·9200	81·4° C.	0·9665	85·3° C
0·9321	82·1	0·9729	87·2
0·9420	82·5	0·9786	88·8
0·9516	83·3	0·9850	91·3
0·9600	84·1	0·9920	94·4

Silbermann has proposed to determine the strength of hydrated alcohol by its rate of expansion by heat, and has constructed an instrument for the purpose (Compt. rend. xxvii. 418). A thermometer is filled up to a certain mark with the spirit at 25° C. and after this liquid has been exhausted of air by the air-pump, an observation is made of the amount by which it expands when heated to 50° C. The amount of alcohol is then found by means of a scale graduated by direct observation upon a number of samples of spirit of known strength. The indications of this instrument are not sensibly affected by the presence of sugar or salts in the liquid.

Another instrument for the same purpose has been constructed and described by **Makin.** (Chem. Soc. Qu. J. ii. 224.)

For further details on alcoholometry, see the new edition of *Ure's Dictionary of Arts, Manufactures and Mines*, vol. i. pp. 44-64.

ALCOHOL-RADICLES. The radicles which, when they replace half the hydrogen in a molecule of water form alcohols, are capable of uniting, though not directly, with chlorine bromine, iodine, cyanogen, oxygen, sulphur, &c., with the radicles of acids, and with metals: in short they exhibit in their chemical relations the character of electro-positive elements or metals. Only a few of them have yet been isolated; and of these, all but one (allyl) belong to the first series of alcohols mentioned in the preceding article, and are represented by the general formula $C^{n}H^{2n+1}$, or $C^{2n}H^{4n+2}$. They are obtained:

1. By the action of sodium, potassium, zinc, &c., at high temperatures, on their iodides or bromides. In this manner ethyl was first isolated by Frankland.—2. By the electrolysis of the acids of the series $C^{n}H^{2n}O^{2}$. The general formula of the decomposition is,

$$C^{n}H^{2n}O^{2} = C^{n-1}H^{2n-1} + CO^{2} + H.$$

In this manner, acetic acid, $C^{2}H^{4}O^{2}$, yields methyl, CH^{3}; valeric acid, $C^{5}H^{10}O^{2}$, yields tetryl or butyl, $C^{4}H^{9}$; caproic acid, $C^{6}H^{12}O^{2}$, yields amyl, $C^{5}H^{11}$; and œnanthylic acid $C^{7}H^{14}O^{2}$ yields hexyl or caproyl, $C^{6}H^{13}$.—3. Some of these radicles, viz. trityl or propyl, tetryl, amyl and hexyl, are also found among the products of the dry distillation of Boghead Cannel coal. (**Gr. Williams**, Chem. Gaz. 1857, pp. 29 and 95.)

Methyl and ethyl are gaseous at ordinary temperatures; trityl, tetryl, amyl, and hexyl, are liquids, the first boiling at 68° C, the second at 108°, the third at 155°, and and the fourth at 202°. They do not unite directly with any of the elementary bodies, and it has not yet been found possible to reproduce from them, by direct union, any of the bodies of the methyl, ethyl series, &c. At the moment of isolation, however, from their iodides by the action of metals, they exhibit a strong tendency to unite with the metal: in this manner, zinc-ethyl, $C^{2}H^{5}Zn$ and zinc-methyl, $C^{2}H^{3}Zn$, are formed by the action of zinc on the iodides of those radicles.

The constitution of these bodies has given rise to considerable discussion. The formulæ CH^{3}, $C^{2}H^{5}$, &c., originally assigned to them by Frankland and Kolbe, represent their vapours as condensed to 1 volume, whereas the usual mode of condensation in organic compounds is to 2 volumes (see ATOMIC VOLUME). For this reason, and likewise because all organic compounds whose formulæ are well established, are found to contain even numbers of hydrogen-atoms, **Gerhardt** (Compt. chim. 1848, 19; 1849, 11) proposed to double the formulæ of these radicles in the free state, making them $C^{2}H^{6}$ or $\left.\begin{matrix}CH^{3}\\CH^{3}\end{matrix}\right\}$, $C^{4}H^{10}$ or $\left.\begin{matrix}C^{2}H^{5}\\C^{2}H^{5}\end{matrix}\right\}$ &c. This duplication of the formulæ was afterwards supported by **Hofmann** (Chem. Soc. J. iii. 121) on the ground that the boiling-points of the consecutive terms of the series of these bodies differ by about 47° C., an interval more than double of that which generally corresponds to a difference of CH^{2} in bodies of the methyl, ethyl, trityl series, &c. But the decisive argument in favour of the double formulæ is afforded by the experiments of Wurtz, who has shown that by the action of mixtures of the iodides of these radicles (iodide of ethyl and iodide of tetryl, for example) with sodium, or by the electrolysis of a mixture of the potassium-salts of two fatty acids, *e. g.* acetate and œnanthylate of potassium, compound radicles are obtained, viz. ethyl-tetryl, $\left.\begin{matrix}CH^{3}\\C^{4}H^{9}\end{matrix}\right\}$, methyl-hexyl $\left.\begin{matrix}CH^{3}\\C^{6}H^{13}\end{matrix}\right\}$ &c.; and moreover that when these mixed radicles are compared with the simple radicles with double formulæ, a regular gradation of physical properties is observed as the number of atoms in the molecule increases. This will be seen from the following table.

Radicle.	Formula.	Specific Gravity at 6° C.	Vapour-Density		Boiling-Point.
			Observed.	Calculated.	
Ethyl-tetryl .	$C^6H^{14} = \left\{\begin{matrix}C^2H^5\\C^4H^9\end{matrix}\right.$	0·7011	3·053	2·972	62° C.
Ethyl-amyl .	$C^7H^{16} = \left\{\begin{matrix}C^2H^5\\C^5H^{11}\end{matrix}\right.$	0·7069	3·522	3·455	88°
Methyl-hexyl .	$C^7H^{16} = \left\{\begin{matrix}CH^3\\C^6H^{13}\end{matrix}\right.$	?	3·426	3·455	82 ?
Tetryl . .	$C^8H^{18} = \left\{\begin{matrix}C^4H^9\\C^4H^9\end{matrix}\right.$	0·7057	4·070	3·939	106
Tetryl-amyl .	$C^9H^{20} = \left\{\begin{matrix}C^4H^9\\C^5H^{11}\end{matrix}\right.$	0·7247	4·465	4·423	132
Amyl . .	$C^{10}H^{22} = \left\{\begin{matrix}C^5H^{11}\\C^5H^{11}\end{matrix}\right.$	0·7413	4·956	4·907	158
Tetryl-hexyl .	$C^{10}H^{22} = \left\{\begin{matrix}C^4H^9\\C^6H^{13}\end{matrix}\right.$	?	4·917	4·907	155
Hexyl . .	$C^{12}H^{26} = \left\{\begin{matrix}C^6H^{13}\\C^6H^{13}\end{matrix}\right.$	0·7574	5·983	5·874	202

It is clear that if the simpler formulæ of tetryl, amyl and hexyl were retained, the accordance between the gradation of properties and increase of atomic weight which the preceding table exhibits would be completely lost.

Viewed in this light, the formation of the simple radicles is strictly analogous to that of the mixed radicles, as will be seen from the following equations:

$$C^2H^5I + C^4H^9I + Zn = ZnI^2 + C^2H^5.C^4H^9$$

and

$$2C^2H^5I + Zn = ZnI^2 + C^2H^5.C^2H^5.$$

ALCOHOLS. The term alcohol, originally limited to one substance, viz. spirit of wine, is now applied to a considerable number of organic compounds, many of which, in their external characters, exhibit but little resemblance to common alcohol. The alcohols are all compounds of carbon, hydrogen, and oxygen. They are divided into several homologous groups, but their rational formulæ may all be derived from one, two, or three molecules of water, $\left.\begin{matrix}H\\H\end{matrix}\right\}O$, $\left.\begin{matrix}H^2\\H^2\end{matrix}\right\}O^2$, $\left.\begin{matrix}H^3\\H^3\end{matrix}\right\}O^3$, by substitution of an organic radicle containing hydrogen and carbon for half the hydrogen in the type. Alcohols are accordingly monatomic, diatomic, or triatomic, *e.g.* Ethyl-alcohol (monatomic) = $\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O$, — Glycol (diatomic) = $\left.\begin{matrix}(C^2H^4)''\\H^2\end{matrix}\right\}O^2$, — Glycerin (triatomic) = $\left.\begin{matrix}(C^3H^5)'''\\H^3\end{matrix}\right\}O^3$

A. **Monatomic Alcohols.** Of these there are several series, containing radicles whose general formulæ are C^nH^{2n+1}, C^nH^{2n-1}, C^nH^{2n-3}, C^nH^{2n-7}.

I. Alcohols of the form $C^nH^{2n+2}O = \left.\begin{matrix}C^nH^{2n+1}\\H\end{matrix}\right\}O$. These alcohols, of which nine, or perhaps ten, are at present known, are intimately related to the fatty acids (p. 50). To every alcohol of this series there corresponds an acid of the series $C^nH^{2n}O^2$, which may be formed from the alcohol by oxidation, O being substituted for H^2. The following table exhibits the names and formulæ of these alcohols, together with those of the corresponding acids:

Alcohols, $\left.\begin{matrix}C^nH^{2n+1}\\H\end{matrix}\right\}O$		Acids, $\left.\begin{matrix}C^nH^{2n-1}O\\H\end{matrix}\right\}O$	
Methylic or protylic . . .	CH^4O	Formic	CH^2O^2
Ethylic or deutylic . . .	C^2H^6O	Acetic	$C^2H^4O^2$
Propylic or tritylic . . .	C^3H^8O	Propionic	$C^3H^6O^2$
Butylic or tetrylic . . .	$C^4H^{10}O$	Butyric	$C^4H^8O^2$
Amylic or pentylic . . .	$C^5H^{12}O$	Valeric	$C^5H^{10}O^2$
Caproylic or hexylic . . .	$C^6H^{14}O$	Caproic	$C^6H^{12}O^2$
Œnanthylic or heptylic . .	$C^7H^{16}O$	Œnanthylic	$C^7H^{14}O^2$
Caprylic or octylic . . .	$C^8H^{18}O$	Caprylic	$C^8H^{16}O^2$
Cetylic	$C^{16}H^{34}O$	Palmitic	$C^{16}H^{32}O^2$
Cerylic	$C^{27}H^{56}O$	Cerotic	$C^{27}H^{54}O^2$
Myricylic	$C^{30}H^{62}O$	Melissic	$C^{30}H^{60}O^2$

These alcohols are also designated as *Hydrates*, or *Hydrated Oxides*, *of Methyl*, *Ethyl*, &c., or as *Methylate*, *Ethylate*, *Tritylate*, *&c.* of *Hydrogen*. The numerical terms *protyl*, *deutyl*, *trityl*, &c. were proposed by Gerhardt. They are in most cases preferable to the older names: but the terms, methyl, ethyl, and amyl, are too much consecrated by use to be discarded.

Methyl-alcohol, or wood-spirit, was first recognised as a compound similar in nature and constitution to common alcohol by Dumas and Peligot in 1835. In the following year, the same chemists showed that ethal (cetyl-alcohol), a substance first obtained from spermaceti by Chevreul in 1823, is also of alcoholic nature. Fusel-oil was recognised as an alcohol somewhat later by Cahours and Balard. Cerotyl-alcohol and melissyl-alcohol were discovered by Brodie in 1848; octyl-alcohol by Bouis in 1851; tetryl-alcohol by Wurtz in 1852; trityl-alcohol by Chancel in 1852, and hexyl-alcohol by Faget in the same year.

Methyl-alcohol is found among the products of the distillation of wood. *Ethyl-alcohol* and the four following alcohols are produced by fermentation of sugar, ($C^6H^{12}O^6$), perhaps in the manner represented by the following equations:

$$C^6H^{12}O^6 = \underset{\text{Ethyl-alcohol.}}{2C^2H^6O} + 2CO^2$$

$$2C^6H^{12}O^6 = \underset{\text{Trityl-alcohol.}}{2C^3H^8O} + \underset{\text{Ethyl-alcohol.}}{C^2H^6O} + 4CO^2 + H^2O$$

$$C^6H^{12}O^6 = \underset{\text{Tetryl-alcohol.}}{C^4H^{10}O} + 2CO^2 + H^2O$$

$$3C^6H^{12}O^6 = \underset{\text{Amyl-alcohol.}}{2C^5H^{12}O} + \underset{\text{Ethyl-alcohol.}}{C^2H^6O} + 6CO^2 + 3H^2O$$

$$2C^6H^{12}O^6 = \underset{\text{Amyl-alcohol.}}{C^5H^{12}O} + \underset{\text{Trityl-alcohol.}}{C^3H^8O} + 4CO^2 + 2H^2O$$

$$5C^6H^{12}O^6 = \underset{\text{Amyl-alcohol.}}{4C^5H^{12}O} + 10CO^2 + 6H^2O$$

$$3C^6H^{12}O^6 = \underset{\text{Hexyl-alcohol.}}{2C^6H^{14}O} + 6CO^2 + 4H^2O$$

Octyl-alcohol is obtained by saponifying castor-oil with potash, and distilling the resulting ricinolate of potassium with excess of the alkali at a high temperature. The ricinolic acid is then converted into octyl-alcohol, sebate of potassium, and free hydrogen:

$$\underset{\text{Ricinolic acid.}}{C^{18}H^{34}O^3} + 2KHO = \underset{\text{Octyl-alcohol.}}{C^8H^{18}O} + \underset{\text{Sebate of potassium.}}{C^{10}H^{16}K^2O^4} + 2H$$

Bouis (Compt. rend. xxiii. 141). Other chemists, however, who have examined this reaction, state that the alcohol produced by it is not octylic, but heptylic. According to **Städeler** (J. pr. Chem. lxxii. 241) two reactions take place simultaneously, the one giving rise to the formation of heptylic alcohol, sebate of potassium, and hydride of methyl (marsh gas), the other to the formation of *methyl-œnanthyl*, an acetone isomeric with caprylic aldehyde, $C^8H^{16}O$, and free hydrogen; thus:

$$\underset{\text{Ricinolic acid.}}{C^{18}H^{34}O^3} + 2KHO = \underset{\text{Heptyl-alcohol.}}{C^7H^{16}O} + \underset{\text{Sebate of potassium.}}{C^{10}H^{16}K^2O^4} + \underset{\text{Hydride of methyl.}}{CH^3.H}$$

$$\underset{\text{Ricinolic acid.}}{C^{18}H^{34}O^3} + 2KHO = \underset{\text{Methyl-œnanthyl.}}{CH^3.C^7H^{13}O} + \underset{\text{Sebate of potassium.}}{C^{10}H^{16}K^2O^4} + H^4$$

According to **Dachauer**, on the contrary (Ann. Ch. Pharm. cvi. 270), the products of the distillation are methyl-œnanthyl and octylic alcohol, the formation of this alcohol differing from that of methyl-œnanthyl only by the elimination of two atoms of hydrogen instead of four. It does not appear that Städeler actually observed the evolution of marsh gas.

Cetyl-alcohol (or ethal) is obtained by decomposing spermaceti (which consists chiefly of *cetin*, $C^{32}H^{64}O^2$) with alkalis, palmitic acid being formed at the same time:

$$\underset{\text{Cetin.}}{C^{32}H^{64}O^2} + KHO = \underset{\text{Cetyl-alcohol.}}{C^{16}H^{34}O} + \underset{\text{Palmitate of potassium.}}{C^{16}H^{31}KO^2}$$

In the same manner, ceryl-alcohol is formed from Chinese-wax, and myricyl-alcohol from bees-wax.

$$\underset{\text{Chinese-wax.}}{C^{54}H^{108}O^2} + KHO = \underset{\text{Ceryl-alcohol.}}{C^{27}H^{56}O} + \underset{\text{Cerotate of potassium.}}{C^{27}H^{53}KO^2}$$

Some of these alcohols have also been formed from the corresponding hydrocarbons C^nH^{2n}, *e.g.* common alcohol from olefiant gas, C^2H^4, and trityl-alcohol from tritylene, C^3H^6, by dissolving these gaseous hydrocarbons in strong sulphuric acid, and decomposing the resulting ethyl-sulphuric or trityl-sulphuric acid by distillation with water. Methyl-alcohol has been formed from marsh-gas, CH^4, by exposing that compound to the action of chlorine in sunshine, whereby chloride of methyl is obtained, and decomposing this body with aqueous potash (Berthelot, Compt. rend. xlv. 916):

$$CH^3Cl + KHO = CH^4O + KCl.$$

The first eight alcohols of the series are liquid at ordinary temperatures. Methylic and ethylic alcohols are mobile watery liquids; the others are more or less oily, the viscidity increasing with the atomic weight. Cetyl-alcohol is a solid fat: cerylic and myricylic alcohols are waxy.

Oxidising agents convert these alcohols into aldehydes, $C^nH^{2n}O$, or acids, $C^nH^{2n}O^2$, in each case with elimination of one atom of water:

$$C^nH^{2n+2}O + O = C^nH^{2n}O + H^2O$$
$$\text{and} \qquad C^nH^{2n+2}O + O^2 = C^nH^{2n}O^2 + H^2O$$

These changes take place on exposing the alcohols to the air, especially in contact with platinum-black, and more quickly on distilling them with a mixture of dilute sulphuric acid and chromate of potassium. The alcohols are also converted into fatty acids by heating them strongly in contact with soda-lime (a mixture of quick lime with caustic soda); *e.g.* amyl-alcohol thus treated yields valerate of sodium.

The alcohols of this series contain one atom of hydrogen replaceable by metals or compound radicles. Many of them, when treated with potassium or sodium, give off hydrogen, and form solid compounds containing 1 atom of the alkali-metal, *e.g.* ethylate of sodium, C^2H^5NaO. In this respect the alcohols partake of the nature of acids.—The compounds thus formed are easily decomposed, and are not easily obtained in a definite form.

On treating these potassium- or sodium-alcohols with the iodide of an alcohol-radicle, iodide of potassium or sodium is precipitated, and an *ether* is formed, that is to say, a compound derived from an alcohol by the substitution of an alcohol-radicle for the basic atom of hydrogen: thus ethylate of sodium with iodide of ethyl yields ethylic ether $(C^2H^5)^2O$, and with iodide of amyl, ethyl-amyl ether, $C^2H^5.C^5H^{11}.O$ (p. 76).

The alcohols are also converted into ethers by the action of strong sulphuric acid chloride of zinc, fluoride of boron, and other powerful dehydrating agents, at a certain temperature. The *ultimate* change is represented by the equation:

$$\underbrace{2\left(\left.\begin{matrix}C^nH^{2n+1}\\H\end{matrix}\right\}O\right)}_{\text{Alcohol.}} - H^2O = \underbrace{\left.\begin{matrix}C^nH^{2n+1}\\C^nH^{2n+1}\end{matrix}\right\}O}_{\text{Ether.}}$$

For the intermediate steps of the process see page 76. This particular change takes place only between certain limits of temperature, *e.g.* for the etherification of common alcohol by sulphuric acid, the limits are 140° and 160° C. At higher temperatures, a further dehydration takes place, and a hydrocarbon C^nH^{2n} is obtained:

$$C^nH^{2n+2}O - H^2O = C^nH^{2n}$$

e.g. common alcohol heated above 160° with strong sulphuric acid, yields olefiant gas C^2H^4.

With the greater number of acids, alcohols yield *compound ethers;* that is to say, salts in which the basic hydrogen of the acid is more or less replaced by the radicle of the alcohol. With monobasic acids, only neutral ethers are formed: thus common alcohol heated with strong acetic acid yields acetate of ethyl, with elimination of water:

$$\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O + \left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O = \left.\begin{matrix}C^2H^3O\\C^2H^5\end{matrix}\right\}O + H^2O$$

The formation of these ethers is greatly assisted by the presence of strong sulphuric or hydrochloric acid, to take up the water. They are commonly prepared either by distilling the alcohol with sulphuric acid, and a salt of the other acid (*e.g.* acetate of ethyl, by distilling alcohol with sulphuric acid and acetate of sodium), or by passing hydrochloric acid gas into an alcoholic solution of the acid. The former method is applicable to the more volatile ethers, the latter to those of higher boiling-point.

With dibasic and tribasic acids, the alcohols generally form *acid ethers* or *alcoholic acids*, that is to say, compounds in which only a portion of the basic hydrogen of the acid is replaced by the alcohol-radicle. Thus, when amyl-alcohol is mixed with sulphuric acid and the mixture kept cool, *amyl-sulphuric acid*, $\left.\begin{matrix}C^5H^{11}\\H\end{matrix}\right\}SO^4$ or $\left.\begin{matrix}(SO^2)''\\C^5H^{11}.H\end{matrix}\right\}O^2$ is produced:

$$\left.\begin{matrix}C^5H^{11}\\H\end{matrix}\right\}O + \left.\begin{matrix}H\\H\end{matrix}\right\}SO^4 = \left.\begin{matrix}C^5H^{11}\\H\end{matrix}\right\}SO^4 + \left.\begin{matrix}H\\H\end{matrix}\right\}O$$

In like manner, phosphoric acid and amyl-alcohol yield amyl-phosphoric acid, $PO^4.C^5H^{11}.H^2$.

Hydrochloric, hydrobromic, and hydriodic acids convert the alcohols of this series into chlorides, &c., of the alcohol-radicles, with elimination of water:

$$\left.\begin{matrix}C^nH^{2n+1}\\H\end{matrix}\right\}O + HCl = C^nH^{2n+1}Cl + H^2O$$

A similar transformation is effected by the chlorides, bromides, and iodides of phosphorus: *e.g.*

$$\underbrace{\left.\begin{matrix}C^5H^{11}\\H\end{matrix}\right\}O}_{\text{Amyl-alcohol.}} + \underbrace{PCl^2.Cl^3}_{\text{Pentachloride of phosphorus.}} = \underbrace{C^5H^{11}Cl}_{\text{Chloride of amyl.}} + HCl + \underbrace{POCl^3}_{\text{Oxychloride of phosphorus.}}$$

With the chlorides of acid radicles, the alcohols form compound ethers, hydrochloric acid being at the same time eliminated:

$$\underbrace{\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O}_{\text{Ethyl-alcohol.}} + \underbrace{C^7H^5O.Cl}_{\text{Chloride of benzoyl.}} = \underbrace{\left.\begin{matrix}C^7H^5O\\C^2H^5\end{matrix}\right\}O}_{\text{Benzoate of ethyl.}} + HCl$$

Persulphide of phosphorus transforms the alcohols of this series into mercaptans (sulphur-alcohols):

$$5C^nH^{2n+2}O + P^2S^5 = 5C^nH^{2n+2}S + P^2O^5$$

2. Alcohols of the form $C^nH^{2n}O = \left.\begin{matrix}C^nH^{2n-1}\\H\end{matrix}\right\}O$ convertible by oxidation into acids of the form $C^nH^{2n-2}O^2$.

Only one term of this series is at present known, viz.:—

Allyl-alcohol or *Hydrate of Allyl*, $C^3H^6O = \left.\begin{matrix}C^3H^5\\H\end{matrix}\right\}O$.

This alcohol was discovered by Cahours and Hofmann in 1856. It is converted by oxidising agents into acrylic aldehyde or acrolein, C^3H^4O, and acrylic acid, $C^3H^4O^2$, and moreover exhibits all the transformations of the bodies of the preceding series (see ALLYL). It is probable that to every acid of the series $C^nH^{2n-2}O^2$ (angelic, terebic, oleic acid, &c), there corresponds an alcohol of the form $C^nH^{2n}O$. These alcohols are isomeric with the aldehydes of the preceding series; *e.g.* allyl-alcohol with propionic aldehyde.

3. Alcohols of the form $C^nH^{2n-2}O = \left.\begin{matrix}C^nH^{2n-3}\\H\end{matrix}\right\}O$. Only one alcohol of this kind is known, viz.:

Camphol, or *Bornean Camphor*, $C^{10}H^{18}O = \left.\begin{matrix}C^{10}H^{17}\\H\end{matrix}\right\}O$. It is a solid substance which, when distilled with anhydrous phosphoric acid, yields the hydrocarbon, $C^{10}H^{16} = C^{10}H^{18}O - H^2O$. It forms neutral ethers with stearic and benzoic acids.

4. Alcohols of the form $C^nH^{2n-6}O = \left.\begin{matrix}C^nH^{2n-7}\\H\end{matrix}\right\}O$, and corresponding to acids of the form $C^nH^{2n-8}O^2$. Three of these alcohols are known, viz.:

Benzyl-alcohol, or *Hydrate of Benzyl*, $C^7H^8O = \left.\begin{matrix}C^7H^7\\H\end{matrix}\right\}O$

Cumyl-alcohol, or *Hydrate of Cumyl*, $C^{10}H^{14}O = \left.\begin{matrix}C^{10}H^{13}\\H\end{matrix}\right\}O$

Sycoceryl-alcohol, or *Hydrate of Sycoceryl*, $C^{18}H^{30}O = \left.\begin{matrix}C^{18}H^{29}\\H\end{matrix}\right\}O$

Benzyl-alcohol was discovered by Cannizzaro in 1853; cumyl-alcohol by Kraut in 1854; these two alcohols are obtained by treating the corresponding aldehydes (bitter-almond oil and cuminol) with an alcoholic solution of potash:

$$\underbrace{2C^7H^6O}_{\text{Hydride of benzoyl.}} + KHO = \underbrace{C^7H^8O}_{\text{Benzyl-alcohol.}} + \underbrace{C^7H^5KO^2}_{\text{Benzoate of potassium.}}$$

Moreover, the aldehydes themselves may be formed from acids, by distilling a mixture of the calcium-salt of the acid with formate of calcium, thus:

$$\underbrace{\left.\begin{matrix}(C^7H^5O)^2\\ Ca''\end{matrix}\right\}O^2}_{\text{Benzoate of calcium.}} + \underbrace{\left.\begin{matrix}(CO.H)^2\\ Ca''\end{matrix}\right\}O^2}_{\text{Formate of calcium.}} = \underbrace{2(C^7H^5O.H)}_{\text{Hydride of benzoyl.}} + \underbrace{2(CO)Ca''O^2}_{\text{Carbonate of calcium.}}$$

Hence it appears that these alcohols may be formed from the corresponding acids.

Benzylic and cumylic alcohols are liquids which volatilise without decomposition. They are converted into aldehydes and acids by the action of oxidising agents; they form compound ethers when treated with a mixture of sulphuric acid and other oxygen-acids (*e.g.* acetate of benzyl, $C^2H^3O^2.C^7H^7$, is formed by treating benzyl-alcohol with a mixture of sulphuric and acetic acids), and yield the chlorides of the corresponding radicles when treated with hydrochloric acid; thus chloride of benzyl, C^7H^7Cl is obtained by treating benzyl-alcohol with strong hydrochloric acid.

With sulphuric acid or chloride of zinc, they yield resinous masses, which are probably hydro-carbons analogous to olefiant gas: anhydrous boracic acid converts benzyl-alcohol into benzyl-ether $(C^7H^7)^2O$. They do not appear to form conjugated acids like ethyl-sulphuric acid. By caustic potash, at high temperatures, they are converted into the corresponding acids and hydrides of the alcohol-radicles; *e.g.*:

$$3\underbrace{(C^7H^7.H.O)}_{\text{Benzyl-alcohol.}} = \underbrace{C^7H^6O^2}_{\text{Benzoic acid.}} + 2\underbrace{(C^7H^7.H)}_{\text{Hydride of benzyl.}} + H^2O$$

Sycoceryl-alcohol was discovered by Warren De la Rue and Hugo Müller, in 1859 (Proc. Roy. Soc. x. 298). It exists in the form of a natural acetic ether in the exudation from an Australian plant, the *Ficus rubiginosa*. This ether is readily obtained in beautiful crystals, and when treated with sodium-alcohol, yields acetic acid and sycocerylic alcohol, in feathery crystals resembling caffeine or asbestos. Treated with nitric acid, it yields an acid which appears to be sycocerylic acid; and with chromic acid, it yields a product which is probably the corresponding aldehyde.

5. Alcohols isomeric with the last, but differing from them in forming conjugated acids with sulphuric acid, phosphoric acid, &c., and in not being converted into acids and aldehydes by the action of oxidising agents. Two of these alcohols are known, viz.:

Phenyl-alcohol, or *Hydrate of Phenyl*, $C^6H^6O = \left.\begin{matrix}C^6H^5\\ H\end{matrix}\right\}O$

Cresyl-alcohol, or *Hydrate of Cresyl*, $C^7H^8O = \left.\begin{matrix}C^7H^7\\ H\end{matrix}\right\}O.$

The former was identified as an alcohol by Laurent, in 1841; the latter was discovered by Williamson and Fairlie, in 1854.

Both of these compounds occur among the products of the destructive distillation of coal, and are separated by fractional distillation. Phenyl-alcohol is also produced by the destructive distillation of salicylic acid:

$$C^7H^6O^3 = C^6H^6O + CO^2.$$

Phenyl-alcohol is solid and crystalline at ordinary temperatures, melts at 35°, and distils without decomposition at about 185°. Cresyl-alcohol is liquid at ordinary temperatures.

These alcohols are easily decomposed by potassium and sodium, like common alcohols, hydrogen being evolved, and compounds formed analogous to ethylate of potassium. They exhibit more decided acid characters than any of the preceding alcohols: phenyl-alcohol indeed is sometimes called *phenic* or *carbolic acid*: it forms a series of salts, called phenates or carbolates, containing 1 at. metal in place of the basic hydrogen. These alcohols are not converted into simple ethers or hydrocarbons by heating with sulphuric acid. Strong nitric acid converts them into nitro-acids, *e. g.* phenyl-alcohol into trinitrocarbolic or picric acid, $C^6H^3(NO^2)^3O$.

With pentachloride of phosphorus, they yield a chloride and a phosphate of the radicle together with hydrochloric acid: *e.g.*

$$\underbrace{4(C^6H^5.H.O)}_{\text{Hydrate of phenyl.}} + PCl^3.Cl^2 = \underbrace{PO^4(C^6H^5)^3}_{\text{Phosphate of phenyl.}} + \underbrace{C^6H^5Cl}_{\text{Chloride of phenyl.}} + 4HCl$$

With the chlorides of the acid radicles, they form compound ethers, thus:

$$\underbrace{C^6H^5.H.O}_{\text{Hydrate of phenyl.}} + \underbrace{C^7H^5O.Cl}_{\text{Chloride of benzoyl.}} = \underbrace{C^7H^5O^2.C^6H^5}_{\text{Benzoate of phenyl.}} + HCl$$

6. Alcohols of the form $C^nH^{2n-8}O = \left.\begin{matrix}C^nH^{2n-9}\\H\end{matrix}\right\}O$. Two only of these bodies are known, viz.:

Cinnamic alcohol, Hydrate of Cinnamyl, or *Styrone*, $C^9H^{10}O = \left.\begin{matrix}C^9H^9\\H\end{matrix}\right\}O$

Cholesterin . . . . . . $C^{26}H^{44}O = \left.\begin{matrix}C^{26}H^{43}\\H\end{matrix}\right\}O$

Styrone is obtained by heating styracin (cinnamate of cinnamyl), with caustic alkalis; cholesterin is found in the bile and other products of the animal economy. Styrone is converted by oxidising agents into cinnamic aldehyde, C^9H^8O, and cinnamic acid, $C^9H^8O^2$, and forms with fuming sulphuric acid a conjugated acid, the barium-salt of which is soluble in water. Cholesterin heated with strong sulphuric acid gives up water and forms a resinous hydrocarbon, $C^{26}H^{42}$ (Zwenger, Ann. Ch. Pharm. lxv. 5). Heated to 200°, with acetic, butyric, benzoic, and stearic acids, it forms compound ethers, with elimination of water, thus:

$$\underbrace{\left.\begin{matrix}C^{18}H^{35}O\\H\end{matrix}\right\}O}_{\text{Stearic acid.}} + \underbrace{\left.\begin{matrix}C^{26}H^{43}\\H\end{matrix}\right\}O}_{\text{Cholesterin.}} = \underbrace{\left.\begin{matrix}C^{18}H^{35}O\\C^{26}H^{43}\end{matrix}\right\}O}_{\text{Stearate of cholesterin.}} + H^2O$$

7. *Saligenin*, $C^7H^8O^2$, an alcohol of the salicyl-series, and *Anisic alcohol*, $C^8H^{10}O^2$, produced by the action of alcoholic potash on hydride of anisyl, $C^8H^7O^2.H$, are probably monatomic; if so, they must contain oxygen-radicles, their rational formulæ being $\left.\begin{matrix}C^7H^7O\\H\end{matrix}\right\}O$ and $\left.\begin{matrix}C^8H^9O\\H\end{matrix}\right\}O$; but they may also be diatomic alcohols, $\left.\begin{matrix}C^7H^6\\H^2\end{matrix}\right\}O^2$ and $\left.\begin{matrix}C^8H^8\\H^2\end{matrix}\right\}O^2$. Their reactions are not sufficiently known to decide the question.

B. **Diatomic Alcohols, or Glycols.** $C^nH^{2n+2}O^2 = \left.\begin{matrix}(C^nH^{2n})''\\H^2\end{matrix}\right\}O^2$. These compounds, discovered by Wurtz, are derived from a double molecule of water, $\begin{matrix}H^2\\H^2\end{matrix}O^2$, in which half the hydrogen is replaced by a diatomic radicle C^nH^{2n}. Four of these have been obtained, viz. *Ethylene-glycol*, or *Hydrate of Ethylene*, $C^2H^6O^2 = \left.\begin{matrix}(C^2H^4)''\\H^2\end{matrix}\right\}O^2$, *Propylene-glycol*, $C^3H^8O^2$, *Butylene-glycol*, $C^4H^{10}O^2$, and *Amylene-glycol*, $C^5H^{12}O^2$. The simple name *glycol* is especially applied to the first of these, just as the term alcohol is especially applied to hydrate of ethyl, the most important of the monatomic alcohols.

Glycol is obtained by treating iodide of ethylene with acetate of silver, whereby diacetate of ethylene is formed:

$$\underbrace{C^2H^4I^2}_{\text{Iodide of ethylene.}} + \underbrace{\left.\begin{matrix}(C^2H^3O)^2\\Ag^2\end{matrix}\right\}O^2}_{\text{2 at. acetate of silver.}} = \underbrace{\left.\begin{matrix}C^2H^4\\(C^2H^3O)^2\end{matrix}\right\}O^2}_{\text{Diacetate of ethylene.}} + 2AgI,$$

and heating the distilled diacetate of ethylene with potash, whereby it is decomposed, like other compound ethers, yielding acetate of potassium and hydrate of ethylene:

$$\left.\begin{matrix}C^2H^4\\(C^2H^3O^2)^2\end{matrix}\right\}O^2 + 2(KHO) = \left.\begin{matrix}C^2H^4\\H^2\end{matrix}\right\}O^2 + \left.\begin{matrix}(C^2H^3O)^2\\K^2\end{matrix}\right\}O^2$$

It was discovered by Wurtz in 1856. The other bodies of the series are obtained by similar processes. They are oily liquids, which distil without decomposition. They contain two atoms of basic hydrogen, one or both of which may be replaced by metals or other radicles.

Glycol treated with sodium yields *monosodic glycol*, $C^2H^4(NaH)O^2$, and this compound, fused with excess of sodium, yields *disodic glycol*, $C^2H^4Na^2O^2$. By treating monosodic glycol with iodide of ethyl, the product with potassium, and this product again with iodide of ethyl, the compounds $C^2H^4(C^2H^5.H)O^2$, $C^2H^4(C^2H^5.K)O^2$, and $C^2H^4(C^2H^5)^2O^2$, are successively obtained. The last is isomeric with acetal, but not identical with it (p. 3), inasmuch as it boils at a temperature 20° below that compound.

Dehydrating agents, such as sulphuric acid and chloride of zinc, do not act upon the glycols in the same manner as upon the corresponding monatomic alcohols. Ethyl-alcohol, $C^2H^5.H.O$, acted upon by sulphuric acid, or chloride of zinc, at certain temperatures, is converted into ether, $(C^2H^5)^2O$, a second atom of ethyl being introduced in place of the remaining hydrogen. If glycol were acted on by these reagents in the same manner, the result would be a glycolic ether containing $(C^2H^4)^2O^2$. Instead of this, the change which takes place is a simple abstraction of water, and the resulting compound is C^2H^4O, a body of only half the atomic weight, and isomeric with aldehyde:

$$C^2H^6O^2 - H^2O = C^2H^4O.$$

Similar results are obtained with the other glycols. The ethers of the diatomic alcohols are therefore isomeric with the aldehydes (see ETHERS, and ETHYLENE, OXIDE OF): and their mode of formation from these alcohols differs from the etherification of the monatomic alcohols in the same manner as the conversion of dibasic acids into anhydrides differs from that of monobasic acids,—the latter being converted into anhydrides by duplication of the radicle: *e.g.* acetic acid = $C^2H^3O.H.O$; acetic anhydride = $(C^2H^3O)^2O$, whereas dibasic acids pass to the state of anhydrides by simple abstraction of water, *e.g.* $SO^4H^2 - H^2O = SO^3$. (Wurtz, Compt. rend. xlvii. 346.)

By treating diatomic alcohols, first with hydrochloric acid and afterwards with potash, compounds are obtained isomeric with the aldehydes, and resembling them in some of their properties, but differing in others; thus, ethylene-glycol, heated in a sealed tube with hydrochloric acid, yields *monochlorhydric glycol*, C^2H^5ClO, a compound intermediate between glycol and chloride of ethylene, $C^2H^4Cl^2$, and formed from glycol by the substitution of Cl for 1 atom of peroxide of hydrogen:

$$C^2H^4.H^2O^2 + HCl = C^2H^4.HO.Cl + H^2O;$$

and this compound, treated with potash, yields oxide of ethylene, a body isomeric with acetic aldehyde:

$$C^2H^4.HO.Cl + KHO = C^2H^4O + H^2O + KCl.$$

This oxide of ethylene resembles aldehyde in being miscible with water, and in forming a crystalline compound with acid sulphite of sodium; but differs from it by boiling at a lower temperature, and by not forming a crystalline compound with ammonia. Similar results are obtained with propylene-glycol. (Wurtz, Compt. rend. xlviii. 100.)

The glycols corresponding to the other series of monatomic alcohols, have not yet been obtained; but several diatomic compound ethers containing benzylene, C^7H^6, have been produced, viz. the acetate, valerate, and benzoate, $C^7H^6.(C^2H^3O)^2.O^2$, &c.; the methylate, ethylate, and amylate, $C^7H^6.(CH^3)^2.O^2$, &c.; the sulphate, $SO^4.C^7H^6$, and the succinate, $C^7H^6.C^4H^4O^2.O^2$. The diatomic alcohol, $C^7H^6.H^2O^2$, corresponding to those compound ethers, has not yet been obtained, not being produced when the ethers are decomposed by alkalis. (W. Wicke, Ann. Ch. Pharm. cii. 363.)

C. **Triatomic Alcohols, or Glycerins.** The general formula of these compounds is $\left.\begin{matrix}C^nH^{2n-1}\\ H^3\end{matrix}\right\}O^3$, the radicle C^nH^{2n-1} being equivalent to three atoms of hydrogen. One term of the series has long been known, viz. ordinary glycerin, $C^3H^8O^3 = \left.\begin{matrix}C^3H^5\\ H^3\end{matrix}\right\}O^3$, the sweet oily liquid obtained in the saponification of fats. It was first shown to be a triatomic alcohol by Berthelot, in 1853. (Compt. rend. xxxvii. 398.)

The neutral fats of the animal body, stearin, palmitin, olein, &c., consist of glycerin, in which three atoms of hydrogen are replaced by acid radicles; and by heating glycerin with acids in different proportions, a large number of compounds may be formed, in which ⅓, ⅔, or the whole of the replaceable hydrogen is thus replaced, the formation of these compounds being accompanied by the elimination of 1, 2, or 3 atoms of water. Thus, with stearic acid, $C^{18}H^{36}O^2$, the following compounds are obtained:

Monostearin $= C^{21}H^{42}O^4 = C^3H^8O^3 + C^{18}H^{36}O^2 - H^2O = \left.\begin{matrix}(C^3H^5)'''\\ H^2.C^{18}H^{35}O\end{matrix}\right\}O^3.$

Distearin $= C^{39}H^{76}O^5 = C^3H^8O^3 + 2C^{18}H^{36}O^2 - 2H^2O = \left.\begin{matrix}(C^3H^5)'''\\ H.(C^{18}H^{35}O)^2\end{matrix}\right\}O^3$

$\left.\begin{matrix}\text{Tristearin}\\ \text{(natural stearin)}\end{matrix}\right\} = C^{57}H^{110}O^6 = C^3H^8O^3 + 3C^{18}H^{36}O^2 - 3H^2O = \left.\begin{matrix}(C^3H^5)'''\\ (C^{18}H^{35}O)^3\end{matrix}\right\}O^3.$

Precisely similar actions take place on heating glycerin with hydrochloric, hydrobromic, or hydriodic acid; but to refer the resulting compounds to the same type, it is best to write the formula of glycerin thus: $C^3H^5(HO)^3$, representing it as a compound of glyceryl with 3 at. peroxide of hydrogen: then the compounds just mentioned may be represented as glycerin in which 1, 2, or 3 at. peroxide of hydrogen are replaced by Cl, Br, I, &c. Thus:

Monochlorhydrin $= C^3H^7ClO^2 = C^3H^8O^3 + HCl - H^2O = C^3H^5Cl(HO)^2$
Dichlorhydrin $= C^3H^6Cl^2O = C^3H^8O^3 + 2HCl - 2H^2O = C^3H^5Cl^2(HO)$
Trichlorhydrin $= C^3H^5Cl^3 = C^3H^8O^3 + 3HCl - 3H^2O$
Bromhydrodichlorhydrin $= C^3H^5Cl^2Br = C^3H^8O^3 + 2HCl + HBr - 3H^2O.$

The chlorhydrins and bromhydrins are likewise produced by treating glycerin with either of the bromides or chlorides of phosphorus. (See GLYCERIN.)

By treating glycerin with the chloride of an acid radicle, or by passing hydrochloric acid gas into a solution of glycerin in the corresponding acid, compounds are formed which may be regarded as glycerin, in which the peroxide of hydrogen is replaced partly by chlorine and partly by the peroxide of the acid radicle; thus with acetic acid [$Ac = C^2H^3O$]:

Acetochlorhydrin $= C^5H^9ClO^3 = C^3H^8O^3 + C^2H^4O^2 + HCl - 2H^2O = C^3H^5.Cl(AcO)(HO).$
Diacetochlorhydrin $= C^7H^{11}ClO^4 = C^3H^8O^3 + 2C^2H^4O^2 + HCl - 3H^2O = C^3H^5.Cl(AcO)^2$
Acetodichlorhydrin $= C^5H^8Cl^2O^2 = C^3H^8O^3 + C^2H^4O^2 + 2HCl - 3H^2O = C^3H^5.Cl^2AcO.$

(For further details, see ACETINS, p. 25.)

All these compounds, when heated with caustic alkalis, or with metallic oxides and water, reproduce the acid and the glycerin; thus stearin heated with caustic potash, yields glycerin and stearate of potassium:

$$\left.\begin{matrix}C^3H^5\\(C^{18}H^{35}O)^3\end{matrix}\right\}O^3 + 3KHO = \left.\begin{matrix}C^3H^5\\H^3\end{matrix}\right\}O^3 + 3\left(\left.\begin{matrix}C^{18}H^{35}O\\K\end{matrix}\right\}O\right)$$

Glycerin may also be formed synthetically in a similar manner to glycol, viz. by heating tribromhydrin, $C^3H^5Br^3$, with acetate of silver, whereby triacetin, $C^3H^5Ac^3O^3$ is formed, and heating this compound with solution of caustic baryta. The other glycerins have not yet been obtained in the free state, but the *acetate of ethyl-glycerin* $(C^2H^3)'''Ac^3O^3$ appears to be obtained, together with glycol, by the action of iodide of ethylene on acetate of silver.

D. **Alcohols not included in any of the preceding groups.**—Berthelot has shown that a considerable number of substances, not usually classed as alcohols, nevertheless possess one essential character of those bodies, viz. that they unite with acids, producing neutral compounds, the formation of which is attended with elimination of water; and these compounds, when heated with alkalis, reproduce the substances from which they have been formed. The bodies in question are chiefly of a saccharine nature, viz. *Mannite*, $C^6H^{12}O^5.H^2O$, the sugar of manna; *Dulcin*, $C^6H^{12}O^5.H^2O$, a saccharine substance from an unknown plant, brought from Madagascar; *Pinite*, $C^6H^{12}O^5$, a sugar from the *Pinus lambertiana*, a tree growing in California; *Quercite*, $C^6H^{12}O^5$, the sugar of acorns; *Erythromannite*, *Erythroglucin*, or *Phycite*, $C^4H^{10}O^4$, a sugar obtained from certain lichens, and from the *Protococcus vulgaris*.—*Orcin*, $C^7H^8O^2$, a sweet crystalline substance, existing in the lichens which yield archil and litmus; *Trehalose*, $C^6H^{10}O^5$, also a kind of sugar; *Glucose*, $C^6H^{12}O^6$, and *Meconin*, $C^{10}H^{10}O^4$, an acrid crystallisable substance, obtained from opium. The following are examples of the compounds formed:

$$\underset{\text{Mannitan.}}{C^6H^{12}O^5} + \underset{\text{Acetic acid.}}{2C^2H^4O^2} - 2H^2O = C^{10}H^{16}O^7$$

$$\underset{\text{Mannitan.}}{C^6H^{12}O^5} + \underset{\text{Stearic acid.}}{4C^{18}H^{36}O^2} - 2H^2O = C^{78}H^{152}O^{11}$$

$$\underset{\text{Mannitan.}}{C^6H^{12}O^5} + \underset{\text{Stearic acid.}}{6C^{18}H^{36}O^2} - 6H^2O = C^{114}H^{216}O^{11}$$

$$\underset{\text{Phycite.}}{C^6H^{14}O^6} + \underset{\text{Benzoic acid.}}{2C^7H^6O^2} - 2H^2O = C^{20}H^{22}O^6 \quad (?)$$

$$\underset{\text{Phycite.}}{C^6H^{14}O^6} + \underset{\text{Benzoic acid.}}{6C^7H^6O^2} - 6H^2O = C^{48}H^{38}O^{12} \quad (?)$$

$$\underset{\text{Glucose.}}{C^6H^{12}O^6} + \underset{\text{Stearic acid.}}{2C^{18}H^{36}O^2} - 3H^2O = C^{42}H^{78}O^7$$

$$\underset{\text{Meconin.}}{C^{10}H^{10}O^4} + \underset{\text{Stearic acid.}}{2C^{18}H^{36}O^2} - 2H^2O = C^{46}H^{78}O^6.$$

these bodies, excepting the last two, with acids, readily
ubstance and the acid. The compounds formed with
nd not easily decomposed; but when treated with dilute
original acid and a fermentable sugar, which reduces
mpt. rend. xli. 452; xlvii. 262.)

$C^2H^3O.H$. [or $C^4H^4O^2 = C^4H^3O.HO$]. *Acetic aldehyde*,
. 274; xiii. 437; Gerh. i. 658).—A volatile liquid
d destructive distillation of alcohol and other organic
ined in an impure state by Döbereiner, who called it
fterwards prepared pure and thoroughly examined by
133; xxxvi. 376). The name *aldehyde* is an abbrevia-
inasmuch as the compound may be regarded as alcohol
gen.

tion of alcohol, either by slow combustion in contact
xide, &c., or by the action of chromic acid, nitric acid,
ulphuric acid and peroxide of manganese (see ALCOHOL,
of alcohol or ether is passed through a tube heated
w combustion of ether.—3. In the decomposition of
also of other ethylic ethers, by a mixture of sulphuric
sium.—4. By heating acetal with glacial acetic acid to
wo days. Acetic ether and alcohol are formed at the
mixture, aldehyde passes over below 60°:

$$\underbrace{H^4O^2}_{\text{cetic cid.}} = \underbrace{C^2H^4O}_{\text{Aldehyde.}} + \underbrace{C^4H^8O^2}_{\text{Acetic ether.}} + \underbrace{C^2H^6O}_{\text{Alcohol.}}$$

ic anhydride:

$$+ C^4H^6O^3 = C^2H^4O + 2C^4H^8O^2.$$

btained boiling above 150°, and probably consisting of
acetic anhydride (Beilstein, Compt. rend. xlviii.
lphuric acid or one of its salts with a mixture of sul-
anganese. This formation of aldehyde is said to take
altogether preclude any previous formation of alcohol
rd, l'Institut, 1857, p. 407).—6. When hemp-oil is
eated to low redness, a liquid is formed containing a
ether with alhehydic or lampic acid (Hess).—7. By
l, lactic anhydride, and lactates with weak bases, such
ide being given off at the same time:

$$O^6 = \underbrace{2C^2H^4O}_{\text{Aldehyde.}} + 2CO + 2H^2O.$$

lso yield considerable quantities of aldehyde when dis-
peroxide of manganese (Städeler, Ann. Ch. Pharm.
sition of animal albumin, fibrin, casein, and gelatin by
d peroxide of manganese, or bichromate of potassium
able fibrin by sulphuric acid and peroxide of manganese
illation of a mixture of acetate and formate of calcium
pricht. See ALDEHYDES, p. 111; also ACETONES, p. 31).

$$\underbrace{C^2H^2Ca''O^4}_{\text{Formate of calcium.}} = \underbrace{2C^2H^4O}_{\text{Aldehyde.}} + \underbrace{2CO^3Ca''}_{\text{Carbonate of calcium.}}$$

80 per cent. alcohol are mixed with 3 pts. peroxide of
and 2 pts. water, and distilled into a receiver kept at a
ixture is gently heated till it begins to froth slightly,
ted as soon as the liquid which passes over begins to
when the distillate amounts to 3 pts. The distillate,
, &c., is mixed with an equal weight of chloride of
iver being constantly kept very cold), till 1½ pt. has
is again rectified with an equal weight of chloride of
r. This last portion is anhydrous, but contains alcohol
well as aldehyde. To purify it, 1 vol. is mixed with 2
d with cold water, and dry ammoniacal gas passed into
rbed rapidly and with great evolution of heat, and the
ls of aldehyde-ammonia. These crystals are washed
and dried as above. (Liebig.)

2. A mixture of 1 pt. 80 per cent. alcohol and 2 pts. water is saturated with chlorine gas (being kept cool all the while), and the liquid distilled, as soon as it has lost the odour of chlorine, till $\frac{1}{30}$ has passed over. That which distils over afterwards is alcohol, which may be collected in a separate receiver and again treated with chlorine as above. The first distillate is again freed from water by repeated distillation so far as to admit of its being saturated with ammonia as above, and yields a very large crop of crystals. (Liebig.)

3. One part of alcohol of sp. gr. 0·842 and 1 pt. of bichromate of potassium are introduced into a capacious tubulated retort and 1⅓ pt. oil of vitriol admitted by drops through the tubulus. The heat evolved by the chemical action which ensues is sufficient to begin the distillation, but towards the end, heat must be applied from without A large quantity of carbonic acid gas is evolved, and the aldehyde condenses in the well cooled receiver, contaminated with only a small quantity of acetic acid and other substances, so that the distillate may be immediately mixed with ether, and ammoniacal gas passed through it as above (W. and R. Rodgers, J. pr. Chem. xl. 248). The modes of formation 5, 6, and 8, above given, may also be advantageously used for the preparation of aldehyde.

To obtain the pure anhydrous aldehyde from the aldehyde-ammonia formed by either of these processes, a solution of 2 pts. of the aldehyde-ammonia in 2 pts. water, is distilled in a water-bath at a gentle but increasing heat, with a mixture of 3 pts. sulphuric acid and 4 pts. water, the distillation being interrupted as soon as the water in the bath begins to boil, and the receiver kept as cold as possible. The hydrated aldehyde which passes over is dried by contact with coarse lumps of chloride of calcium in a well closed vessel, and then rectified in a water-bath, at a temperature not exceeding 30°.

Properties.— Aldehyde is a thin, transparent, colourless liquid, having a pungent suffocating odour. Its specific gravity is 0·80002 at 0° (Kopp); 0·80551 at 0° (Pierre). It boils at 20·8° when the barometer stands at 760 mm. (Kopp); at 22°, with the barometer at 758·2 mm (Pierre). Vapour-density 1·532 (Liebig); (by calculation, 1·520, for a condensation to 2 vol.) It does not redden litmus, even when it is dissolved in water or alcohol.

Aldehyde may be regarded either as the *hydride of acetyl*, $C^2H^3O.H$, or as the *hydrate* or *hydrated oxide of vinyl*, $\left.\begin{matrix}C^2H^3\\H\end{matrix}\right\}O$. Its chemical reactions may for the most part be explained equally well on either hypothesis; but according to the recent observations and calculations of Kopp, the formula $C^2H^3O.H$, is most in accordance with the observed atomic volume of aldehyde, which is between 56·0 and 56·9, the calculated atomic volume being 56·2, as deduced from the first formula, and 51·8 as deduced from the second. (See ATOMIC VOLUME: also Graham's Chemistry, 2nd Ed. vol. ii. p. 581.)—Aldehyde is isomeric, but not identical, with the oxide of ethylene, $C^2H^4.O$, recently discovered by Wurtz.

Aldehyde mixes in all proportions with *water*, *alcohol*, and *ether*. A mixture of 1 pt. aldehyde and 3 pts. water boils at 37°. Chloride of calcium added to the aqueous solution separates the aldehyde, which then rises to the surface.

Aldehyde dissolves *sulphur* and *phosphorus*, also *iodine*, forming a brown solution.

Dry sulphurous acid gas passed into anhydrous aldehyde surrounded with cold water, is rapidly absorbed, 11 pts. of aldehyde absorbing 9 pts. of the gas, with increase of volume. The absorption-coefficient of aldehyde for sulphurous acid gas is 1·4 times as great as for alcohol, and 7 times as great as for water. (Geuther and Cartmell, Ann. Ch. Pharm. cxi. 17.)

Decompositions.—1. Aldehyde is very inflammable, and burns with a blue flame.—2. When kept in close vessels, it is often converted into a less volatile liquid, or into two crystalline bodies, which are isomeric modifications of aldehyde (p. 109).—3. In vessels containing *air*, it absorbs oxygen, and is converted into acetic acid; the action is greatly accelerated by the presence of platinum black.—4. *Chlorine-water* and *nitric acid* also convert aldehyde into acetic acid.—5. By strong *sulphuric acid*, it is thickened and blackened, also by *phosphoric anhydride.*—6. When an aqueous or alcoholic solution of aldehyde is heated with *potash*, it becomes yellowish and turbid, and a red-brown resinous mass, the *resin of aldehyde*, separates on the surface, the liquid at the same time emitting a spirituous and disagreeably pungent odour. The solution is afterwards found to contain formate and acetate of potassium. This is the most characteristic reaction of aldehyde.—7. When vapour of aldehyde is passed over red-hot *potash-lime*, acetate of potassium is formed and hydrogen evolved:

$$C^2H^4O + KHO = C^2H^3KO^2 + 2H.$$

8. *Potassium* (or *sodium*) acts on aldehyde in the same manner as on alcohol, hydrogen being evolved and aldehydate of potassium, C^2H^3KO, produced.—9. When an

s heated with *oxide* or *nitrate of silver*, mixed with a
silver is reduced, forming a beautiful specular coating
etate of silver is formed in the solution. This reaction
t for aldehyde.—10. *Chlorine gas* in contact with alde-
s part of the aldehyde, forming chloride of acetyl, which
sed aldehyde, forming the compound, $C^2H^4O.C^2H^3OCl$.
cid gas is passed into anhydrous aldehyde surrounded
is absorbed, and the liquid separates into two layers,
turated with hydrochloric acid, and the upper of *oxy-*
(A. Lieben, Compt. rend. xlvi. 662):

$$+ 2HCl = C^4H^8Cl^2O + H^2O.$$

artmell (Ann. Ch. Pharm. cxii. 13; Proc. Roy. Soc.
action is the body, $C^6H^{12}Cl^2O^2$, which, when gently
rbonic acid, splits up into aldehyde, C^2H^4O, and
$^2Cl^2O^2$, may be regarded as a triple molecule of alde-
n O replaced by Cl^2.—12. Aldehyde mixed with twice
d saturated in the cold with hydrochloric acid gas,
which, when treated with ethylate of sodium, forms
chloride of phosphorus, aldehyde yields chloride of
ntabromide of phosphorus it yields bromide of ethyli-
l by ethylate of sodium into acetal (p. 4).—14. *Chloro-*
nverts aldehyde into chloride of vinyl, C^2H^3Cl, with
d carbonic anhydride. (Harnitz Harnitzky, Ann.

$$OCl^2 = C^2H^3Cl + HCl + CO^2.$$

to act upon aldehyde in the same manner as hydro-
very unstable.—16. When aqueous aldehyde is satu-
gas, a viscid oil is formed, consisting of *hydrosul-*
$^{26}S^7 = SH^2.6C^2H^4S$. On treating this oil with strong
hydrosulphuric acid escapes, and a white crystalline
yl-mercaptan, C^2H^4S, a compound related to aldehyde,
ercaptan, C^2H^6S, to alcohol.—17. *Cyanic acid* vapour
quietly absorbed by anhydrous aldehyde at 0°; but
e mixture becomes heated, gives off carbonic anhydride,
difies into a mass consisting of *trigenic acid*, $C^4H^7N^3O^2$,
f cyamelide, aldehyde-ammonia, and other products

$$3CNHO = C^4H^7N^3O^2 + CO^2.$$

y be regarded as a monobasic acid, inasmuch as it
replaceable by metals. Thus, when potassium is
ydrogen is evolved, and aldehydate of potassium,
aporation in vacuo this salt may be obtained in the
ver, C^2H^3AgO, is produced when oxide of silver is
onia. The most important of these salts is the am-

ldehyde-ammonia, *Acetyl-ammonium*, $C^2H^4O.NH^3 =$
l and Ammonium, $C^2H^3.NH^4.O$. — Ammoniacal gas
bines with it, giving off heat, and forming a white
yde be previously mixed with ether, the compound
the finest are obtained by mixing a concentrated
nmonia with ether (Liebig).—The crystals are acute
dges of about 85°, often truncated with the faces of
e); they are transparent, colourless, shining, strongly
ommon sugar, and very friable. The compound melts
tils unaltered at 100°. In the state of vapour or in
rmeric paper. Its odour is ammoniacal, but has like-
e (Liebig).—It dissolves very easily in water, less

flammable. In contact with the air, especially if also
llow, and acquires an odour resembling that of burnt
tion it may again be obtained in the colourless state,
hich is soluble in water, and contains acetate of am-
cal salt. Even the weaker acids, such as acetic acid,
compound. Sulphuric acid and potash act upon it in

the same manner as upon aldehyde. Its aqueous solution, digested with oxide of silver, reduces part of this oxide and dissolves the rest, forming aldehydate and acetate of silver mixed with ammonia, from which the oxide of silver is precipitated by baryta-water, and reduced when the liquid is heated, while acetate of barium remains in solution.

Aldehyde-ammonia treated with hydrosulphuric acid yields *thialdine*, $C^6H^{13}NS^2$:

$$3(C^2H^3O.NH^4) + 3H^2S = C^6H^{13}NS^2 + (NH^4)^2S + 3H^2O.$$

Similarly, with hydroselenic acid, it yields *selenaldine*, $C^6H^{13}NSe^2$. With bisulphide of carbon it forms *carbothialdine*:

$$\underbrace{2(C^2H^3O.NH^4)}_{\text{Aldehyde-ammonia.}} + CS^2 = \underbrace{C^5H^{10}N^2S^2}_{\text{Carbothialdine.}} + 2H^2O$$

Aldehyde-ammonia heated with hydrocyanic and hydrochloric acids yields *alanine*:

$$\underbrace{C^2H^4O.NH^3}_{\text{Aldehyde-ammonia.}} + \underbrace{CNH}_{\text{Hydrocyanic acid.}} + H^2O + HCl = \underbrace{C^3H^7NO^2}_{\text{Alanine.}} + NH^4Cl.$$

But when a mixture of aldehyde-ammonia and hydrocyanic acid, with sufficient hydrochloric acid to give it a distinct acid reaction, is left to itself for some time, in a closed vessel, especially in sunshine, colourless needle-shaped crystals are formed, consisting of *hydrocyanaldine*, $C^9H^{12}N^4$:

$$3(C^2H^4O.NH^3) + 3CNH + 2HCl = C^9H^{12}N^4 + 2NH^4Cl + 3H^2O.$$

Aldehyde-ammonia heated in a sealed tube to 120° C. is decomposed, and yields two layers of liquid, the upper consisting chiefly of aqueous ammonia, with small quantities of other volatile bases, while the lower, which remains behind on distilling at 200°, contains a substance which has the composition $C^{10}H^{15}NO$, and may be regarded as an *aldehydate of tetravinylium*: $= C^2H^3O.N(C^2H^3)^4$. Its formation is represented by the equation:

$$5(C^2H^3O.NH^4) = C^{10}H^{15}NO + 4NH^3 + 4H^2O.$$

By treating this compound with baryta-water, the group C^2H^3O is replaced by HO. and *hydrate of tetravinylium* is formed.

$$2[C^2H^3O.N(C^2H^3)^4] + BaH^2O^2 = (C^2H^3O)^2Ba + 2[N(C^2H^3)^4.H.O].$$

(Babo, J. pr. Chem. lxxii. 88; Chem. Gaz. 1858, 136.)

Concentrated aqueous solutions of aldehyde-ammonia and nitrate of silver yield, when mixed, a fine-grained white precipitate, probably consisting of $NO^3Ag.2(C^2H^3O.NH^4)$. It dissolves very sparingly in alcohol, easily in water.

Sulphite of Aldehyde-ammonia, or *Sulphite of Vinyl-ammonium*, $C^2H^3(NH^4)O.SO^2 = (C^2H^3.NH^4).SO^3$.—Sulphurous acid gas passed into a solution of aldehyde-ammonia in absolute alcohol is rapidly absorbed; and if the liquid be kept cool, sulphite of aldehyde-ammonia is deposited in small white prisms, which may be washed with alcohol and dried in vacuo. This compound is isomeric with taurin, $C^2H^7NO^3S$—a substance produced by the metamorphosis of a sulphur-acid contained in the bile—but possesses very different properties. It is soluble in water and in aqueous alcohol, very sparingly in absolute alcohol. The crystals decompose slowly in the air at ordinary temperatures, turn brown and lose weight at 100°, and are completely decomposed at higher temperatures, leaving a spongy carbonaceous residue. Acids decompose them, liberating aldehyde and sulphurous anhydride. When strongly heated with potash-lime, they give off ethylamine (Gössmann, Ann. Ch. Pharm. xci. 122), or rather perhaps dimethylamine:

$$C^2H^3.NH^4.SO^3 + KHO = C^2H^7N + SO^4.HK.$$

COMPOUND OF ALDEHYDE WITH ACETIC ANHYDRIDE, $C^6H^{10}O^4 = C^4H^6O^3.C^2H^4O$.—When 1 at. acetic anhydride and 1 at. pure aldehyde are heated together in a sealed tube to 180° C. for about 12 hours, they unite and form a liquid compound which may be freed from unaltered aldehyde and acetic anhydride by fractional distillation, further purified by washing the portion which passes over above 140° with hot water, and dehydrated over chloride of calcium. It then boils at 168°. It has an alliaceous odour and slight acid reaction, probably arising from decomposition during distillation. Heated with hydrate of potassium, it yields acetate of potassium, giving off the peculiar odour of aldehyde when similarly treated. This reaction distinguishes the compound from Wurtz's acetate of ethylene (acetate of glycol), $C^2H^4(C^2H^3O)^2.O^2$ with which it is isomeric: for that compound heated with caustic alkalis, yields hydrate of ethylene (glycol), without any odour of aldehyde. (Geuther, Ann. Ch. Pharm. cvi. 249.)

Aldehyde appears to form similar compounds with *benzoic* and *succinic anhydrides*.

TH CHLORIDE OF ACETYL, $C^4H^7ClO^2 = C^2H^4O.C^2H^3OCl$.
ehyde heated together to 100° for three hours in a
quid which distils completely between 90° and 140° C.
tion a considerable quantity of liquid, boiling between
lighter than water; is very slowly decomposed by cold
vater; and dissolves easily in dilute potash, forming
m, and yielding free aldehyde which is partly resinised
silver also decomposes it, forming chloride and acetate
n, Compt.-rend. xlvii. 174.)
ced, according to Wurtz (Ann. Ch. Phys. [3] xliv. 58),
, by introducing perfectly dry aldehyde into a large
Its formation is due to the union of the chloride of
remaining aldehyde (compare p. 106). Wurtz, how-
lecule of aldehyde ($C^4H^8O^2$), having 1 at. H replaced by

s.—Aldehyde is susceptible of four isomeric modifica-

Pure aldehyde sealed up in a tube changes in the
uid, which has a pleasant ethereal odour, boils at about
in with potash; it may be exposed to the air without
vithout mixing. (Liebig)
about half its bulk of water and a trace of sulphuric
C., changes into a liquid which is no longer miscible with
by agitation with water, and rectification over chlo-
°. It has a peculiar aromatic burning taste, and is
sparingly also in water. Its vapour-density is 4·583,
volumes, corresponds to the formula $C^6H^{12}O^3$. When
water, it readily changes into an acid, and then becomes
lly also crystals separate from it at the same time.
antity of sulphuric or nitric acid, it is converted into
busch, Ann. Ch. Pharm. lxvi. 155.)
lid and fusible Elaldehyde.—Anhydrous aldehyde, en-
pieces of chloride of calcium, for two months in winter,
, which, however, disappeared again after a fortnight,
of them could be perceived in the liquid.—These crys-
liquid which solidifies at 0°, and boils at 94°, giving off
57. In the fused state, this substance has an ethereal
ess pungent than that of aldehyde; its taste is some-
a blue flame; its vapour passed through a red-hot
ous mixture, and a small quantity of a liquid having
f vitriol blackens the crystals slowly in the cold, imme-
tals may be heated with potash-ley for some time with-
idify again on the surface as the liquid cools. When
silver, they throw down the silver in the form of a
coating. When dissolved in ether, they do not absorb
altered. (Fehling, Ann. Ch. Pharm. xxvii. 319.)
nn. Ch. Pharm. cxi. 16) have obtained a similar modi-
lehyde with sulphurous acid gas, dissolving the result-
the acid with chalk, distilling, and treating the dis-
rates the remaining common aldehyde in the resinous
aldehyde in the form of a clear liquid, which boils at
obtained by Weidenbusch, and solidifies at 10°, starting
to melt at 10°.
dehyde.—Anhydrous aldehyde kept for some time in a
bottle, frequently deposits transparent, colourless, four-
the whole liquid like a network. The crystals remain
ger heat sublime undecomposed, in the form of transpa-
r hard needles, which are easily pulverised, inodorous,
luble in water, but easily soluble in alcohol and ether
ing pure aldehyde to the cold of winter for several
e crystals, mixed, however, with a larger quantity of
d and easy to pulverise; at 120° they sublime without
re suffered to evaporate in the air, the vapour condenses
g). Heated for some time to 180° in sealed tubes
nary aldehyde. (Geuther, Ann. Ch. Pharm. cvi. 252.)

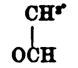
us body obtained by heating aldehyde with potash, either
tion, especially the latter. It is also formed in solutions

of the alkalis in alcohol, and in acetal, when kept for a long time. According to Weidenbusch (Ann. Ch. Pharm. lxvi. 153) it is a substance of a fiery orange colour which is reduced by drying at 100°, to a powder, having a paler tint. It dissolves in alcohol and ether, sparingly in water, scarcely at all in alkalis, partially in strong sulphuric acid, from which it is precipitated by water. When purified as completely as possible, it contains 76·4 per cent. of carbon, and 8·0 per cent. of hydrogen: its formation is accompanied by that of acetic, formic and acetylous [?] acid; at the same time a pungent odour is evolved, proceeding from a peculiar substance which adheres obstinately to the resin. This substance is oily and volatile when first produced, but soon thickens, even when alone and still more quickly under the influence of nitric acid, and is converted into a golden-yellow, viscid resin, which smells like cinnamon, dissolves in alcohol and ether, and sparingly in water, and is different from the true aldehyde-resin.

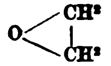
ALDEHYDES. A class of organic compounds intermediate between alcohols and acids. They are derived from alcohols by abstraction of 2 atoms of hydrogen, and are converted into acids by addition of 1 atom of oxygen: thus in the fatty acid series:

$$\underbrace{C^nH^{2n+2}O}_{\text{Alcohol.}} - H^2 = \underbrace{C^nH^{2n}O}_{\text{Aldehyde.}},\ \text{and}\ \underbrace{C^nH^{2n}O}_{\text{Aldehyde.}} + O = \underbrace{C^nH^{2n}O^2}_{\text{Acid.}}$$

Aldehydes may be regarded as derivatives: 1. Of a molecule of hydrogen HH, half the hydrogen being replaced by an oxygen-radicle: *e.g.* benzoic aldehyde or bitter-almond oil, $C^7H^6O = C^7H^5O.H.$—2. Of a molecule of water, half the hydrogen being replaced by a monatomic hydrocarbon, *e.g.* benzoic aldehyde = $\left.\begin{matrix}C^7H^5\\H\end{matrix}\right\}O$; acetic aldehyde = $\left.\begin{matrix}C^2H^3\\H\end{matrix}\right\}O$. — 3. Of a molecule of water, in which the whole of the hydrogen is replaced by a diatomic hydrocarbon: *e.g.* acetic aldehyde = $(C^2H^4)''O$. They are indeed isomeric with the ethers or anhydrides of the diatomic alcohols (p. 103), but differ from these ethers in the structure of the diatomic radicle which they contain; acetic aldehyde for example is the oxide of ethylidene, $CH^3.CH$, whereas the isomeric compound glycolic ether is the oxide of ethylene, $CH^2.CH^2$; thus



Aldehyde.



Oxide of ethylene.

The following are the aldehydes at present known.

1. Aldehydes of the form $C^nH^{2n}O = \left.\begin{matrix}C^nH^{2n-1}\\H\end{matrix}\right\}O = C^nH^{2n-1}O.H.$

Acetic aldehyde	C^2H^4O	Caprylic aldehyde [?]	$C^8H^{16}O$
Propionic „	C^3H^6O	Euodic „	$C^{11}H^{22}O$
Butyric „	C^4H^8O	Lauric „	$C^{12}H^{24}O$
Valeric „	$C^5H^{10}O$	Palmitic „	$C^{16}H^{32}O$
Œnanthylic „	$C^7H^{14}O$		

2. Aldehyde of the form $C^nH^{2n-2}O = \left.\begin{matrix}C^nH^{2n-3}\\H\end{matrix}\right\}O = C^nH^{2n-3}O.H.$

Acrylic aldehyde, or Acrolein, C^3H^4O.

3. Aldehyde of the form $C^nH^{2n-4}O = \left.\begin{matrix}C^nH^{2n-5}\\H\end{matrix}\right\}O = C^nH^{2n-5}O.H$

Campholic aldehyde, or Camphor, $C^{10}H^{16}O$.

4. Aldehydes of the form $C^nH^{2n-8}O = \left.\begin{matrix}C^nH^{2n-9}\\H\end{matrix}\right\}O = C^nH^{2n-9}O.H.$

Benzoic aldehyde, or Bitter-almond oil, C^7H^6O.
Cuminic aldehyde, or Oil of Cumin, $C^{10}H^{12}O$.

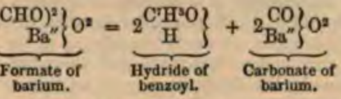
5. Aldehyde of the form $C^nH^{2n-10}O = \left.\begin{matrix}C^nH^{2n-11}\\H\end{matrix}\right\}O$, or $C^nH^{2n-11}O.H.$

Cinnamic aldehyde, or Oil of Cinnamon, C^9H^8O.

6. Aldehydes of the form $C^nH^{2n-8}O^2 = \left.\begin{matrix}C^nH^{2n-9}O\\H\end{matrix}\right\}O$, or $C^nH^{2n-9}O^2.H.$

Salicylic aldehyde, or Salicylous acid, $C^7H^6O^2$.
Anisylic aldehyde, or Anisylous acid, $C^8H^8O^2$.

to known alcohols may all be formed from those
exposure to the air in contact with platinum-black, or
dilute sulphuric acid and peroxide of manganese or
lehydes may also be prepared from the corresponding
by distilling a mixture of the barium-salt of the acid
rmate of barium, thus:



$$\underbrace{\left.\begin{matrix}\text{CHO})^2\\ \text{Ba}''\end{matrix}\right\}O^2}_{\text{Formate of barium.}} = \underbrace{2\left.\begin{matrix}C^7H^5O\\ H\end{matrix}\right\}}_{\text{Hydride of benzoyl.}} + \underbrace{2\left.\begin{matrix}CO\\ \text{Ba}''\end{matrix}\right\}O^2}_{\text{Carbonate of barium.}}$$

xcvii. 368; **Piria**, Ann. Ch. Phys. [3] xlviii. 113).
of Williamson's method of producing compound ace-

acetic, propionic, butyric, &c. are produced by the
sein, and gelatin with peroxide of manganese and
ed in the destructive distillation of organic acids, as
œnanthylic aldehyde from ricinolic acid. Caprylic
ts to be produced (together with the corresponding
acid with excess of potash. According to **Bouis**
cid, $C^{10}H^{18}O^2$, is formed at the same time:

$$\underbrace{{}^4O^3}_{\text{lic}} = \underbrace{C^8H^{16}O}_{\text{Caprylic aldehyde.}} + C^{10}H^{18}O^2.$$

Cimento, iv. 401), the acid formed is sebacic acid

$$+ 2O = \underbrace{C^8H^{16}O}_{\text{Caprylic aldehyde.}} + \underbrace{C^{10}H^{18}O^4}_{\text{Sebacic acid.}}$$

sed to take place simultaneously with that by which
duced (p. 97). The aldehyde might indeed be pro-
. According to **Städeler**, on the other hand (J. pr.
ct $C^8H^{16}O$ thus formed is not caprylic aldehyde, but
body isomeric with it (p. 97).
directly from plants, either existing ready formed in
volatile oils on distilling the plants with water. Thus,
essential part of bitter-almond oil, cinnamic alde-
aldehyde of Roman cumin oil, and salicylic aldehyde
a. Oil of rue consists principally of euodic aldehyde,
auric aldehyde (C. G. **Williams**, Proc. Roy. Soc. ix.
to be capric aldehyde. Benzoic aldehyde is also pro-
ydrogen (evolved by the action of zinc on hydrochlo-
ydrocyanic being formed at the same time:

$$y + HH = C^7H^5O.H + CyH.$$

onds with the representation of aldehydes as hydrides

xcept palmitic aldehyde, which is a fatty solid) are
t decomposition. They are very prone to oxidation,
or less quickly by mere exposure to the air. In con-
idation, they easily reduce the oxides of the noble
hydes are converted by hydrate of potassium, espe-
the corresponding alcohols, and the potassium-salt of
ith bitter almond oil:

$$+ KHO = \underbrace{C^7H^8O}_{\text{Benzyl-alcohol.}} + \underbrace{C^7H^5KO^2}_{\text{Benzoate of potassium.}}$$

c aldehyde are decomposed in like manner. The al-
sponding to the fatty acids) and acrylic aldehyde, are
: acetic aldehyde treated with potash yields acetate
brown resinous mass.
and for the most part crystalline, compounds with the
ls, *e. g.* bitter-almond oil with acid sulphite of sodium,

$C^7H^6O.SO^3NaH = \left.\begin{matrix}C^7H^5\\ Na\end{matrix}\right\}SO^3 + H^2O = \left.\begin{matrix}SO\\ Na.C^7H^5\end{matrix}\right\}O^2 + H^2O$. These compounds are for the most part soluble in water and alcohol, but insoluble in saturated solutions of the alkaline bisulphites. Hence by shaking a liquid containing an aldehyde with excess of such a saturated solution, the aldehyde may be completely separated in the form of a crystalline compound. This is an excellent method of purifying those volatile oils which have the constitution of aldehydes. The acid sulphites of potassium and sodium are, generally speaking, the best adapted for this purpose, as the compounds which they form with the aldehydes are much less soluble in the solution of the sulphite than the corresponding ammonium-compounds, and therefore crystallise more readily. From all these compounds, the aldehyde may be set free by the action of the stronger acids, or by neutralisation with an alkaline carbonate, and may then be obtained in the pure state by distillation.

The aldehydes of the first series combine with ammonia, forming crystalline compounds like aldehyde-ammonia, $C^2H^4O.NH^3$, (p. 106), and valeral-ammonia, $C^5H^{10}O.NH^3$. These compounds treated with sulphuretted hydrogen yield sulphur-bases, like thialdine, $C^6H^{13}NS^2$, and valeraldine, $C^{15}H^{31}NS^2$, thus:

$$3(C^5H^{10}O.NH^3) + 3H^2S = C^{15}H^{31}NS^2 + (NH^4)^2S + 3H^2O.$$

Heated with hydrocyanic and hydrochloric acids, they yield bases similar to the last, but containing oxygen in place of sulphur: *e. g.*:

$$C^5H^{10}O.NH^3 + CNH + ClH + H^2O = \underbrace{C^6H^{13}NO^2}_{\text{Leucine.}} + NH^4Cl.$$

Acrylic aldehyde appears also to combine directly with ammonia, forming a white amorphous compound.

The remaining aldehydes yield with ammonia peculiar amides called hydramides, the formation of which is attended with elimination of 3 atoms of water, *e. g.*

$$\underbrace{3(C^7H^6.O)}_{\substack{\text{Benzoic}\\ \text{aldehyde.}}} + N^2H^6 = \underbrace{N^2(C^7H^6)^3}_{\substack{\text{Hydrobenza-}\\ \text{mide.}}} + 3H^2O$$

$$\underbrace{3(C^7H^6O^2)}_{\substack{\text{Salicylic}\\ \text{aldehyde.}}} + N^2H^6 = \underbrace{N^2(C^7H^6O)^3}_{\text{Salhydramide.}} + 3H^2O$$

Aldehydes also combine with anhydrous acids (anhydrides), forming compounds which are isomeric, but not identical with the diacid glycol-ethers. Thus acetic aldehyde unites with anhydrous acetic acid, forming the compound, $C^2H^4O.C^4H^6O^3$, isomeric with acetate of ethylene, $C^2H^4.(C^2H^3O)^2.O^2$;—also with anhydrous benzoic and succinic acids. Valeral forms with anhydrous acetic, and benzoic acids, the compounds $C^5H^{10}O.C^4H^6O^3$ and $C^5H^{10}O.C^{14}H^{10}O^3$, isomeric with acetate and benzoate of amylene, $C^5H^{10}.(C^2H^3O)^2.O^2$ and $C^5H^{10}.(C^7H^5O)^2.O^2$. These compounds heated with caustic alkalis yield acetates, benzoates, &c., of the alkali-metals, and reproduce the original aldehydes, whereas the acetates, benzoates of ethylene, amylene, &c., under the same circumstances, yield glycols, or hydrates of ethylene, amylene, &c. (Geuther, Ann. Ch. Pharm. cvi. 249; Guthrie u. Kolbe, ibid. cix. 296.)

The calcium and barium-salts of certain monobasic organic acids, butyric and valeric acids, for example, yield by dry distillation, together with acetones (p. 31), compounds isomeric with the aldehydes, but distinguished from them by not combining with ammonia: these compounds are called *butyral*, *valeral*, &c. (Chancel, J. Pharm. [3] vii. 143; Limpricht, Ann. Ch. Pharm. xc. 111.)

Many of the aldehydes are susceptible of polymeric transformations. Acetic aldehyde exhibits three or four such modifications (p. 108); and benzoic aldehyde is very apt to pass into the solid substance benzoin, $C^{14}H^{12}O^2$.

The acetones or ketones are aldehydes in which the basic atom of hydrogen is replaced by an alcohol-radicle, thus:

$$\text{Acetone} = \left.\begin{matrix}C^2H^3\\ C\,H^3\end{matrix}\right\}O = \left.\begin{matrix}C^2H^3O\\ C^2H^3\end{matrix}\right\}$$

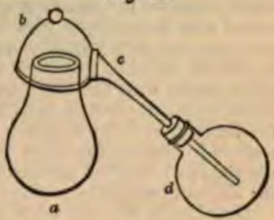
$$\text{Valerone} = \left.\begin{matrix}C^5H^9\\ C^4H^9\end{matrix}\right\}O = \left.\begin{matrix}C^5H^9O\\ C^4H^9\end{matrix}\right\}$$

$$\text{Valeracetone} = \left.\begin{matrix}C^5H^9\\ CH^3\end{matrix}\right\}O = \left.\begin{matrix}C^5H^9O\\ CH^3\end{matrix}\right\} \text{ or } \left.\begin{matrix}C^2H^3\\ C^4H^9\end{matrix}\right\}O = \left.\begin{matrix}C^2H^3O\\ C^4H^9\end{matrix}\right\}$$

ALDIDE. The generic name applied by L. Gmelin, in his Handbook, to the aldehydes, the latter term being by him restricted to acetic aldehyde. In Gmelin's system, the term includes several organic anhydrides and other compounds not generally regarded as aldehydes. (Handb. vii. 192.)

for distillation, much used by the older chemists. It
s adapted a head *b*, of conical shape, and having its
lepressed lower than
ich rise and are con-
wn into the circular
d part, whence they
, into the receiver *d*.
ed in the laboratory,
which is simpler and
the alembic has its
residues of distilla-
f the body *a*; and in
head is very con-
ucts, while the more
the receiver. Glass
manufactories of sulphuric acid for effecting the final

Fig. 4.



A name given by the alchemists to one of the double
um, 2($NH^4Cl.HgCl$) + H^2O, also called *Salt of wisdom*.
CHRYSOBERYL.)

. The alchemical name for the oxychloride of anti-
chloride (butter of antimony) into water.

silicate of alumina, occurring in New Jersey, and crys-
netimes in oblique prisms. The following analyses of
Crossley:

. . . .	52·16	52·00
. . . .	26·08	25·42
. . . .	1·94	1·54
. . . .	1·21	5·39
. . . .	10·69	10·38
. . . .	7·92	5·27
	100	100·00

ANCES. (See NUTRITION.)

er extract, probably a mixture of several compounds,
n (*Alisma Plantago*) (Jach, Repert. Pharm. iv. 174;

crystalline substance, sometimes deposited on the
a aromatica. The crystals are white and capillary, with
greeable odour of the plant. They sublime undecom-
ut at higher temperatures they melt and form a brown
n cold, but soluble in warm water, forming a neutral
tals unaltered; so likewise does the distillate obtained
lve readily in alcohol of 80 per cent., in ether, oil of
nate of potassium, and caustic ammonia. Nitric acid
ve, but merely colours them yellow. (Handwört. d.

ned by Schunck by the action of nitric acid on alizarin,
er to be identical with Laurent's phthalic acid (which

^2O [or $C^{20}H^{6}O^{6}+4HO$]. *Lizaric acid.*—A red colour-
er. It was first prepared by Robiquet and Colin
), who obtained it by digesting pounded madder with
g the gelatinous extract thereby obtained with alcohol,
n, after concentration, with dilute sulphuric acid. A pre-
hich, when washed, dried, and sublimed, yielded alizarin
the red colour of native chromate of lead. Alizarin is
ed (J. pr. Chem. v. 362), and with the somewhat impure
from madder by Persoz and Gaultier de Claubry
and has been prepared in the pure state by Schunck
Debus (ibid. lxv. 351), and by Wolff and Strecker
to exist ready formed in madder, but to be produced
and ruberythric acid. (See MADDER.)

Preparation according to Wolff and Strecker. — Madder is exhausted with boiling water; the decoction is precipitated by sulphuric acid; and the washed precipitate while yet moist, is boiled with a concentrated solution of alumina in hydrochloric acid, which dissolves the colouring matters, and leaves a dark brown residue. The solution mixed with hydrochloric acid deposits red flakes, consisting of alizarin, more or less contaminated with purpurin and resinous matters. This precipitate is dissolved in alcohol, or in dilute ammonia, and the solution is treated with hydrate of alumina, which unites with the colouring matters; and the alumina-compound thus formed is boiled with carbonate of soda, which dissolves the purpurin and leaves the alizarin in combination with the alumina. Lastly, this compound, after being freed from resinous matters by digestion in ether, is decomposed by hot hydrochloric acid which dissolves the alumina; and the alizarin thus separated is washed, dried by simple exposure to the air, and purified by repeated crystallisation from alcohol.

According to **Schwartz** (Bull. de la Soc. industr. de Mulhouse, 1856, No. 135), the purest alizarin is obtained by subliming on paper an alcoholic extract of madder having at least 35 times the colouring power of the root itself. According to **Plessy** and **Schützenberger** (Compt. rend. xliii. 167), when an extract of madder prepared with wood-spirit, is triturated with a tenfold quantity of water, and heated to 250° in a closed vessel, the water on cooling becomes filled with crystals of alizarin; and the fused extractive mass remaining at the bottom of the vessel, yields, when again treated in the same manner, an additional quantity of very pure alizarin.

Anderson, by treating opianic acid ($C^{10}H^{10}O^5$ = alizarin + $2H^2O$) with sulphuric acid, obtained a colouring matter (probably alizarin), which yielded all the madder colours with alumina and iron mordants. (Edinb. Phil. Trans. xxi. 1, 204.)

Alizarin in the anhydrous state forms red prisms, inclining more or less to yellow, according to the size of the crystals. It combines with 2 at. water, forming scaly crystals like mosaic gold. These crystals give off their water at 100 °C., becoming opaque and of a darker colour. At 215° the compound sublimes, yielding a crystalline sublimate of the same composition as alizarin dried at 100°; nevertheless a considerable quantity of charcoal is always left behind.

The following are the mean results of the analyses of alizarin dried between 100° and 120° or sublimed:

	Calculation.		Robiquet.	Schunck.	Debus.	Rochleder.
10 C . .	120	68·96	69·72	69·4	68·96	67·93
6 H . .	6	3·45	3·74	4·0	3·78	3·77
3 O . .	48	27·59	26·54	26·6	27·26	28·30
$C^{10}H^6O^3$	174	100·00	100·00	100·0	100·00	100·00

Schunck assigns to crystallised alizarin the formula $C^{14}H^{10}O^4 + 2H^2O$. According to the formula $C^{10}H^6O^3$, alizarin is closely related to Laurent's chloronaphthalic acid, $C^{10}H^5ClO^3$. The latter, when boiled with nitric acid, yields phthalic and oxalic acid, like alizarin (*vid. inf.*).—According to recent researches, the formula of alizarin is $C^{14}H^8O^4$ (see SUPPLEMENT).

Alizarin dissolves but sparingly in water, even at the boiling heat; but according to **Plessy** and **Schützenberger** (*loc. cit.*) its solubility is much increased by heating to higher temperatures in close vessels, 100 pts. of water dissolve 0·034 pt. of alizarin at 100° C.; 0·035 at 150°; 0·82 at 200°; 1·70 at 225°; and 3·16 pts. at 250°.

Alcohol and ether dissolve it, forming yellow solutions. It is not decomposed by hydrochloric acid. Strong sulphuric acid dissolves it, forming a brown solution from which the alizarin is precipitated by water in orange-coloured flakes. Nitric acid at the boiling heat dissolves it, with evolution of red vapours, forming phthalic acid and probably also oxalic acid (**Wolff** and **Strecker**):

$$\underbrace{C^{10}H^6O^3}_{\text{Alizarin.}} + H^2O + 4O = \underbrace{C^8H^6O^4}_{\text{Phthalic acid.}} + \underbrace{C^2H^2O^4}_{\text{Oxalic acid.}}$$

It is also converted into phthalic acid by boiling with ferric chloride or nitrate (**Schunck**). Chlorine converts it, when suspended in water, into a yellow substance which dissolves in alkalis without much colour, and yields a colourless sublimate when heated.

Alizarin dissolves in caustic alkalis and in alkaline carbonates, forming deep purple solutions, from which it is precipitated by acids in orange-coloured flakes. The ammoniacal solution gives off all its ammonia by evaporation, and forms with the chlorides of barium and calcium purple precipitates which become nearly black when dry. The potash solution is completely decolorised by lime-water, a precipitate being formed containing $2C^{10}H^6O^3.3CaHO$, or $2C^{20}H^6O^6.3(CaO,HO)$. With baryta, in a similar manner, two compounds are formed, viz. $2C^{10}H^6O^3.3BaHO$ and $C^{10}H^6O^3.2BaHO$. Alumina decolorises an alcoholic solution of alizarin, forming a beautiful red lake. An ammoniacal solution of alizarin forms with salts of magnesium, iron, copper, and silver,

or bluish iridescence. The silver precipitate becomes
e alcoholic solution of alizarin forms with an alcoholic
a purple precipitate containing $2C^{20}H^{10}Pb''O^{6}.3Pb''O$,
$H^{6}O^{3}.2Pb''O$, according to Debus.

s.)

usalz. The word *alkali* is used in various senses. In
sual sense, it is applied to four substances only: hydrate
of sodium (soda), hydrate of lithium (lithia), and hy-
be supposed to exist in the aqueous solution of ammonia).
applied to the hydrates of the so-called *alkaline earths*
nd to a large number of organic substances both natural
ully described in the articles ALKALOIDS and AMMONIUM-
re sometimes spoken of as *alkalis proper*, when it is
them from the other alkalis.

e described with sufficient detail in the articles specially
ne this article to a discussion of those properties which
n order, as far as possible, to define the essential nature
upon what grounds this or that particular body is classed
ill probably be best attained by tracing the most im-
by which the word alkali, which was at first the name
to be the generic name of an indefinite number of bodies.
d in chemistry to designate the soluble part of the ashes
d (carbonates of sodium and potassium). It was, how-
similar substances which were obtained by other pro-
tartar, and to carbonate of potassium obtained by heat-
substances obtained by these processes, and by others
as identical, or at most, as mere varieties of the same
re, not yet used as a generic name, but as the specific
. The character which was chiefly depended upon for
r substances was the property of effervescing with acids.
be characteristic of, and essential to, alkaline bodies,
h century. Another property of alkali which was early
acids, and power of destroying their most distinctive
possessing these properties, carbonate of ammonium,
the thirteenth century, was, from the beginning of the
s a kind of alkali. The power of alkali to change many
ed at a later period than the properties above mentioned,
who also knew that colours which had been thus altered

d in 1736, by Duhamel, that there existed two essentially
From this time, three kinds of alkali were recognised,
kali, and volatile alkali, corresponding respectively to
to their carbonates.

far on in the eighteenth century, the power of efferves-
as an essential property of alkalis. Boyle had indeed
e alkali could be obtained by distillation over quick lime
onger effervesced with acids, although it retained all its
otwithstanding isolated observations of this kind, non-
rded rather as subordinate varieties of the ordinary
rent substances.

a very early date, that quick lime altered some of the
eration was expressed by calling alkali, which had not
and alkali which had been so acted on, *caustic*. The
by Basil Valentine (latter half of the fifteenth century)
ebendigen Kalk") which it imparted to the alkali. And
ombined with an active principle — "matter of fire" —
ally to water (when slaked), and completely to alkali,
Helmont (circ. 1640) regarded the substance taken up
acid, whence the heat evolved in the action of water on
y as 1764, supposed the lime-salt of a peculiar acid,
uring the burning of lime, and that when this salt was
rresponding alkaline salt (caustic alkali) was obtained.
alkalis suggested the name of the acid which Meyer

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the change which takes place in the ideas attached to the same
eyer should have attributed what we consider an exaltation of the
acid. (See ACIDS, p. 40.)

The true nature of the difference between caustic and mild alkalis was discovered by Black in 1755. Black's investigation of this subject occupies so important a place in the history of general chemical theory, that it is worth while to consider a little in detail his experiments and the conclusions he derived from them.

His first observation was that quick lime, when deadened by exposure to air, became heavier, not lighter, as was to be expected, if the change which took place consisted in the escape of *fire-matter*. He made a similar observation in the case of magnesia (a substance which he had previously found to be distinct from lime). He found further that magnesia, in the state in which it effervesces with acids, lost considerably in weight when calcined, and that it then no longer effervesced with acids, although it formed with them salts exactly similar to those of effervescing magnesia. In order to find out what was the substance which effervescing magnesia lost when calcined, he repeated the calcination in a retort connected with a well cooled receiver. In this experiment, he obtained nothing but a small quantity of water; it occurred to him, however, that a gas might have escaped, and that this gas might be the same as that which is evolved during the solution of *magnesia alba* (effervescing magnesia) in acids. Following out this supposition, he came to the conclusion that the effervescing magnesia which is precipitated by a mild alkali from a solution of calcined (not effervescing) magnesia in acid, could obtain the gas, which caused it to effervesce when dissolved, from no source except the alkali. Hence he concluded further that the mild alkalis contain the same gas as is expelled from *magnesia alba* by calcination; that, when they combine with acids, this gas is separated and causes effervescence; and that, when a magnesia salt is precipitated by a mild alkali, the gas leaves the latter and unites with the magnesia, in combination with which it is precipitated. These conclusions were verified by the following quantitative experiment. A weighed quantity of *magnesia alba* was calcined; it then dissolved in sulphuric acid without effervescence. The solution was precipitated by mild vegetable alkali (carbonate of potassium), the precipitate washed, dried, and weighed: its weight was almost exactly the same as that of the original *magnesia alba*, and it behaved in every respect like that substance. On a further examination of the gas, which is expelled by acids from the mild alkalis and lime, and from *magnesia alba*, Black found it to be the same as that which is formed during fermentation, and gave it the name *fixed air*.

From the sum of his observations, Black deduced the following general conclusions. The effervescing earths and alkalis contain fixed air, which can be expelled from the former by heat, though not from the latter, but which is expelled from both by acids; the alkalis and earths are caustic when they contain no fixed air, and therefore their causticity does not depend on the presence of any peculiar constituent, but is a property possessed by them in a state of purity; quick lime renders the alkalis caustic, not by imparting to them any principle of causticity, but by the removal from them of fixed air; lastly fixed air partially neutralises the alkalis by combining with them, insomuch as it destroys their causticity.

Two of the most important effects which the adoption of Black's theory had upon the received ideas of alkalinity were that it caused chemists to perceive (which they had not done before), a necessary opposition between the causticity of an alkali and its power of effervescing with acids, and caused the term alkali to be transferred from the carbonated to the caustic alkalis.

Besides the substances to which the name alkali was first given, it was soon perceived that certain kinds of earth possessed, in some degree, alkaline properties; that is to say, the power of effervescing when acted on by acids, and of neutralising their acid properties. Earths which possessed these qualities were called *terræ absorbentes*, or *terræ alcalinæ*, and were long supposed to owe their peculiarities to the presence of alkali as one of their constituents.

It is not easy to make any precise statement as to the degree of similarity or of difference which was supposed to exist between these bodies and alkali proper. The difficulty arises partly from the fact, that, until they had acquired some idea of the principles of chemical analysis, chemists had no sure means of ascertaining the identity or individuality of chemical substances, and hence often called different bodies by the same name, or, on the other hand, gave different names to the same substance when obtained by different processes; partly also, from the word alkali having been used formerly as now in various senses: by Lemery, for instance, to include all substances which effervesce with acids; by Stahl, to include all those which neutralise acids; by many others, however, to denote none but the substances now known as the alkaline carbonates. This uncertainty in the use of the word is not surprising, when we remember that our present more extensive knowledge does not enable us to point out any one difference of fundamental importance between the alkalis and the alkaline earths. The different solubility in water of their carbonates probably furnishes a more exact distinction than any other single property. This character was pointed out by

ric difference. He distinguished earths from alkalis by
er have of precipitating the former from their solutions,
others by their capability of completely neutralising acids.
he most part, been ever since retained.

uss with much detail early ideas relating to the ultimate
d alkaline earths. A similarity of constitution between
s was soon suspected; in consequence of which Neumann,
hteenth century, endeavoured to get a metal from quick
c chemists, both alkalis and earths were, like metallic
odies. Lavoisier, though he regarded metallic calces as
s the alkalis and earths among elementary bodies, inas-
means of decomposing them. He considered it probable,
oxygen, and suggested that the earths might be oxides
er affinity for oxygen than carbon, and therefore could
pts were made by Lavoisier's followers to verify these
rm failure seemed almost to have proved the elementary
on, when, in 1807, Sir Humphry Davy succeeded in re-
e galvanic current. The composition of volatile alkali
ascertained by Berthollet in 1785. After the discovery
, it was long supposed by Davy and Berzelius that am-
The idea that aqueous ammonia contained the oxide of
ewise existed in the ammonia-salts, was suggested by
ONIUM.)

mical theory, the relations of the alkalis to other sub-
ion of them as hydrates, or as water in which half the
al, or compound radicle. (See TYPES.)

y modern chemistry to the old list of alkalis was morphia,
rner in 1805, but first fully described by him in 1817.
kali, or alkaloid which became known; but, when the
was directed to its existence, it was soon found to be
of compounds (see ALKALOIDS). Of late years, a large
many points of resemblance to the natural alkaloids have
ocesses. The constitution of these artificial alkalis is
ammonium: they represent hydrate of ammonium in
an electro-positive radicle (in most cases a hydrocarbon),
which nitrogen is replaced by phosphorus, arsenic, or

e common to the mineral alkalis and to many of the

oluble in water, the alkalis proper much more so than
y neutralise completely the strongest acids, and with
g in some degree, alkaline properties. (3) Their aqueous
rosive action on vegetable and animal substances; (4)
om most of their acid solutions as hydrates or as oxides;
colouring matters; for instance, they turn litmus, which
e, they turn turmeric brown, and syrup of violets and
. The extent to which the various alkalis dissolve in
degree in which they possess the last three properties
sing them in a greater degree than the rest. The action
o belong to all metallic hydrates which are soluble in
hydrates of lead, silver, and mercury, in a degree cor-
ility.

ls concerning alkalis and alkaline earths, see **Kopp**,
. and iv.).—G. C. F.

determination of the amount of real alkali in alkaline
the commercial carbonates of potassium and sodium
da), in wood-ashes, solutions of caustic and carbonated
ike that of the strength of acids, may be made either
lysis.

lkalimetry is merely a particular case of the general
tion," described in the article ANALYSIS, VOLUMETRIC
an alkali by the amount of a standard acid solution
st introduced by Descroizille, afterwards perfected
er by **Mohr**. (Lehrbuch der chemisch-analytischen
855.)

hydrochloric acid generally used for the purpose, Mohr
se it can be weighed with greater accuracy than any

liquid acid, and because its standard solution may be kept for any length of time without change. To obtain it pure, the commercial acid, which is generally contaminated with the oxalates of potassium and calcium, is finely pounded, and treated with a quantity of lukewarm water sufficient to dissolve only a portion of it; the solution is filtered and left to crystallise; and the crystals are collected on a filter and dried in the air, till they no longer adhere to each other or to the paper. The acid is thus obtained pure, and containing exactly $C^2H^2O^4 + 2H^2O$, the atomic weight of which is 126.

The standard solution is best made of such a strength that 1000 cubic centimetres (1 litre), shall contain exactly one $\frac{1}{2}$-gramme-atom (*i.e.* 1 atom expressed in $\frac{1}{2}$-grammes) of the acid. This is effected by dissolving in water $\frac{126}{2} = 63$ grammes of the crystals, and diluting the solution to the bulk of 1 litre. 1000 c. c. of this solution contain one $\frac{1}{2}$-gramme-atom of acid: hence 2 c. c. contain 1 milligramme-atom of acid, and saturate 2 milligramme-atoms of a caustic alkali (KHO or NaHO), 1 milligramme of an anhydrous alkali (K^2O or Na^2O), or of an alkaline carbonate (CO^3K^2 or CO^3Na^2.)

To estimate the value of a sample of commercial potash or soda, 3 or 4 grammes of it are first ignited in a platinum crucible in order to determine the amount of water contained in it. The residue is then dissolved in water; a few drops of litmus are added; and the standard acid is gradually added from a burette till the first appearance of a purple-red or wine-red colour. This takes place when a little more than half the alkaline carbonate is decomposed by the oxalic acid: for the first portions of carbonic acid disengaged by the oxalic acid, unite with the remaining portion of alkaline carbonate to form acid carbonate, and it is only when half the alkali has been neutralised in this way that the carbonic acid is actually set free and reddens the litmus. After this stage has been attained, the oxalic acid must be very cautiously added till the purple-red produced by the carbonic acid, just passes into a bright yellowish-red, indicating the presence of free oxalic acid, and showing that the whole of the alkali is neutralised by that acid. Each c. c. of acid thus employed corresponds to 1 milligramme of caustic alkali, or to one $\frac{1}{2}$-milligramme of alkaline carbonate, *i.e.* to 0·040 grm. caustic soda (NaHO), 0·056 grm. caustic potash (KHO), 0·069 grm. carbonate of potassium (CO^3K^2), and 0·053 grm. of carbonate of sodium. The amount of caustic alkali or alkaline carbonate is then found by a simple proportion; thus:

100 : 5·3 : : number of c. c. employed : amount of carbonate of sodium.

By operating on 100 times the $\frac{1}{2}$-milligramme-atom (*e.g.* 6·9 grms. of carbonate of potassium, or 5·3 grms. of carbonate of sodium), all calculation is saved: for as this amount, if perfectly pure, would require 100 c. c. of acid for its saturation, the number of c. c. actually required indicates at once the percentage of alkaline carbonate. The burettes commonly used contain 50 c. c., and are graduated into half c. c.; so that by operating on 50 times the $\frac{1}{2}$-milligramme-atom, the number of divisions employed indicates the percentage.

In operating upon alkaline carbonates in the manner just described, it is difficult to notice the exact moment when the wine-red colour of the litmus due to the presence of free carbonic acid, changes to the light red produced by oxalic or other strong acid. For this reason Mohr recommends the following, called the *residual method.* The standard acid is added till the colour of the litmus is distinctly bright red; the solution is then heated to boiling, and a slight excess (5 to 10 c. c.) of acid is added. The hot solution is freed from carbonic acid by agitation and by drawing air through it by means of a glass tube, and then neutralised with a standard solution of caustic soda (ANALYSIS, VOLUMETRIC), till the colour just changes from red to blue. Since the acid and alkaline solutions neutralise each other, volume for volume, it is only necessary to deduct the number of cubic centimetres employed of the latter from that of the former, and calculate the amount of alkali from the residue. In estimating the strength of caustic alkaline solutions, this residual method is of course unnecessary.

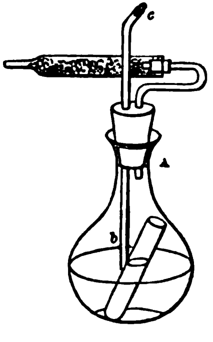
To determine the proportion of caustic alkali and alkaline carbonate in a mixture of the two, two equal portions of the solution must be taken: one of them treated with chloride of barium, whereby the alkaline carbonate is converted into chloride, and carbonate of barium is precipitated. The liquid is filtered and the quantity of caustic alkali determined in the filtrate as above. The second portion of the solution is neutralised with the standard acid, without previous treatment with chloride of barium, and the total amount of alkali, existing both in the caustic state and as carbonate, is thereby determined. The first result deducted from the second, gives the quantity of alkali existing as carbonate.

If it be preferred to make these estimations with the ordinary English weights and measures, the standard solution of oxalic acid may be made by dissolving 63 grains ($\frac{1}{2}$-grain-atom) of the crystallised acid in water and diluting the solution to 1000 grain-measures at 60° F. This quantity of the solution will then neutralise 1 grain-atom of a caustic alkali (40 grains of soda NaHO, or 56 grains of potash KHO), and ½-grain-atom of alkaline carbonate (69 grains of CO^3K^2, or 53 grains of CO^3Na^2), and by operating on $\frac{1}{10}$ of these quantities of the substance to be tested, the percentages will be given at once by the number of grain-measures of the standard acid employed.

A convenient method of estimating by volumetric analysis the proportion of potash and soda in a caustic mixture of the two, has been kindly communicated to the Editor by Mr. John Dale of Cornbrook, near Manchester. It depends upon the fact that acid tartrate of potassium, though moderately soluble in water, is but very sparingly, if at all, soluble in a liquid containing acid tartrate of sodium. The method is as follows: Add to the mixture a standard solution of tartaric acid till an acid reaction just becomes perceptible; the alkalis are thereby converted into neutral tartrates; then add a second quantity of tartaric acid equal to the first, so as to convert them into acid tartrates: the whole (or nearly the whole) of the acid tartrate of potassium then separates. Next filter off the solution of acid tartrate of sodium, and add a standard solution of caustic soda till the liquid just exhibits an alkaline reaction. The quantity of the soda solution thus added is equal to the amount of soda present in the mixture.—The quantity of tartaric acid required to form acid tartrate with the soda, subtracted from the total quantity added to the mixture of the two alkalis, gives the quantity required to form acid tartrate with the potash; and thus the amount of potash is determined. This method would scarcely be applicable where scientific accuracy is required; but, for rapid estimation in commercial practice, it is found to give good results.

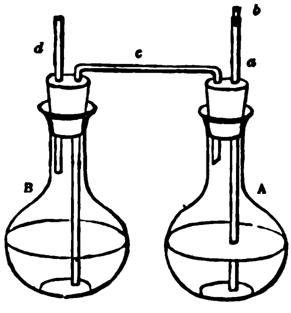
Alkalimetry by Weight-analysis.—The proportion of alkali in the commercial carbonates of potassium and sodium may be estimated by determining the quantity of carbonic anhydride evolved when the carbonates are decomposed by an acid: for 22 parts of carbonic anhydride (CO^2) correspond to 69 parts of carbonate of potassium (CO^3K^2), and to 53 parts of carbonate of sodium (CO^3Na^2). The apparatus employed is the same as that described in the article ACIDIMETRY; but the method of using it is slightly different. A weighed quantity of the carbonate to be examined is dissolved in warm water in the flask A, and a quantity of hydrochloric or dilute sulphuric acid more than sufficient to decompose the carbonate, is placed in a short test-tube *b*, which is carefully introduced into the flask, so that it may rest against the side. The apparatus having been then weighed, the extremity of the tube *c* is closed by a plug of wax, and the flask is tilted so that the acid may run over into the alkaline liquid. When the evolution of gas ceases, the flask is heated to complete the decomposition; the wax plug is removed and air drawn through the apparatus to remove the carbonic acid remaining in it; and the flask after cooling is again weighed to ascertain the loss of carbonic acid. At the conclusion of the experiment, a piece of blue litmus-paper must be thrown into the flask, to try whether the liquid is acid; if not, more acid must be added, and the process repeated.

Fig. 5.



The apparatus of Will and Fresenius (*fig.* 6) may also be used. The alkali dissolved in water is then placed in the flask A, and strong sulphuric acid in B; and the whole apparatus is weighed; the tube *a b* is closed with a wax plug; and suction is applied by the mouth at the end of the tube *d*, so as to draw a few bubbles of air from A into B. On discontinuing the suction the pressure of the air forces a small quantity of the acid in B into the flask A, whereby a portion of the alkaline carbonate is decomposed. This process is repeated as long as any gas continues to be evolved, after which the flask A is heated, and the experiment completed in the manner just decribed.

Fig. 6.



If the alkaline carbonate contains any caustic alkali, which may be known (in the absence of sulphide), by its solution having an alkaline reaction after the addition of excess of chloride of barium, another equal portion must be mixed with about one-third of its weight of carbonate of ammonium, and 3 parts of quartz-sand (to prevent caking), and heated till the water and ammonia are expelled; the dry residue is then decomposed as above. The excess of alkaline carbonate obtained in the second determination is due to the caustic alkali in the sample, which is converted into carbonate by ignition with the carbonate of ammonium; and from it the amount of caustic alkali is easily calculated; thus for soda:

$$CO^3Na^2 : 2NaHO \ [\text{or } CO^2.NaO : NaO.HO] = 106 : 80.$$

The sulphites, hyposulphites, and sulphides of the alkali-metals, which often occur in commercial samples of alkali, especially in "ball-soda," introduce errors both into the volumetric and the weight-analyses: into the former, by neutralising a portion of the test-acid, and into the latter by evolving sulphurous acid or sulphuretted hydrogen, which would be estimated as carbonic acid. When the amount of alkali is to be determined by the volumetric method, these compounds may be decomposed by igniting the substance with chlorate of potassium, whereby they are all converted into sulphates. For the carbonic acid estimation, they may be oxidised by adding a small quantity of neutral chromate of potassium to the solution in the flask, before commencing the decomposition.

The carbonates of the earths, which would introduce similar errors, may be removed by dissolving the alkaline carbonate in water and filtering.

ALKALOIDS. *Organic Alkalis, Organic Bases.*—At the beginning of this century, the only substances in which alkaline properties had been recognised were potash, soda, ammonia, and the alkaline earths (see Alkali). In 1817, Sertürner drew attention to the existence in opium of a substance whose alcoholic solution acted upon vegetable colours like the solutions of the alkalis, which combined directly with acids, forming neutral salts, soluble in water, and giving the usual reactions of the acids from which they were formed; and which was precipitated from solutions of its salts by the mineral alkalis. To this substance, Sertürner gave the name *morphine*, and in consequence of its possessing the properties just mentioned, regarded it as a kind of alkali. After the discovery of morphine, it was soon found that many vegetable products which had been long known as exerting marked physiological effects (*e. g.* cinchona bark, nux vomica, tobacco, &c.), contained similar alkaline principles. The number of such natural *alkaloids* now known is very great, and includes many substances which cannot in any strict sense be termed alkalis, but which are connected by such insensible gradations (between intermediate terms) with substances decidedly alkaline, that they must be regarded as possessing essentially the same chemical nature as the latter. Since 1848, a great number of organic alkalis have been obtained artificially. Some of these rival potash and soda in the degree of their alkalinity, while in others the existence of alkaline properties is barely perceptible.

The only property which is possessed by all alkaloids, whether natural or artificial, is that of combining directly with acids to form salts possessing a certain degree of stability, and capable, when dissolved in water, of producing the ordinary phenomena of saline double decomposition. Those alkaloids, whose salts possess any considerable degree of stability, generally exhibit, when dissolved in water or alcohol, an alkaline reaction with vegetable colours.

Most of the natural alkaloids contain carbon, hydrogen, nitrogen, and oxygen, and are, at ordinary temperatures, solid, and not volatile without decomposition. Some natural alkaloids contain carbon, hydrogen, and nitrogen only; these are, for the most part, liquid at ordinary temperatures, and can be distilled without decomposition. The greater number of the artificial alkalis are composed of carbon, hydrogen, and nitrogen; some, however, contain oxygen in addition. In both natural and artificial alkaloids, hydrogen may be replaced by chlorine, bromine, iodine, peroxide of nitrogen, &c. Alkaloids have also been obtained artificially, in which nitrogen is replaced by phosphorus, arsenic, antimony, or bismuth. (See Phosphines, Arsines, &c.)

Most of the alkaloids, as they are obtained in the free state, correspond in composition to ammonia, NH^3, rather than to the fixed alkalis; that is to say, they form salts by direct union with acids, without elimination of water or any other substance. In order to make them strictly comparable to the fixed alkalis, they require, like ammonia, the addition of H^2O to their formulæ: they may then be considered as hydrates of compound radicles analogous to ammonium. A few alkaloids, however, are known which, when dehydrated as far as possible, correspond precisely to the fixed alkalis; *e.g.* hydrate of tetrethylium, $C^8H^{21}NO = C^8H^{20}N.H.O$. These bodies, for the most part, resemble potash and soda very closely in properties.

The constitution of most of the artificial alkaloids is tolerably well known. The processes by which they are obtained show that they must be considered as ammonia, or as hydrate of ammonium, in which the hydrogen is replaced wholly, or in part, by a compound radicle generally composed of carbon and hydrogen (see Amides, Ammonium-bases). The phosphorus, arsenic, &c. alkaloids are similarly related to phosphide, arsenide, &c. of hydrogen, PH^3, AsH^3, &c. The constitution of the natural rfectly understood. They are probably, like the artificial ia; but it is unknown by what radicles the hydrogen is

the most important nitrogen-alkaloids, natural and arti-

ammonia, forming salts by direct union with acids.

	Formula.	Source or Mode of Formation.
	$C^2H^6N^2$	. Acetamide heated in hydrochloric acid gas.
	$C^9H^{18}N^2$	. Action of ammonia on acetone.
NE.)		
	$C^{30}H^{47}NO^7$	. *Aconitum Napellus.*
	$C^3H^7NO^2$	. Hydrochloric and hydrocyanic acids on aldehydammonia.
	$C^3H^5N,$	. Nitrous ether on creatine (Dessaignes).
	$C^4H^8N^4$	. Distillation of ethylcyanamide (Cahours and Cloez).
	$C^8H^{13}NO$	From aldehydammonia (Babo).
	$C^{10}H^{15}NO$	
	$C^3H^7N.$	
	$C^6H^9Br^2N$	. Tribromide of allyl on ammonia
	$C^9H^{13}Br^2N.$	
	$C^{21}H^{18}N^2$	. Potash on hydrobenzamide.
	$C^{25}H^{26}N^2.$	
	$C^3H^5N^5O$	. Strong acids or alkalis on cyanamide.
	$C^5H^{13}N.$	
	$C^{10}H^{23}N.$	
	$C^9H^{21}N.$	
	$C^8H^{19}N.$	
	$C^{15}H^{33}N.$	
)		
	$C^{24}H^{24}N^2O^3$	. Action of heat on anishydramide.
	$C^{23}H^{26}N^2O^4$	. Cinchona bark.
	$C^4H^8N^2O^3$	. *Asparagus officinalis*, and other plants.
	$C^{17}H^{23}NO^3$	. *Atropa belladonna, Datura Stramonium.*
	$C^{10}H^{10}N^2$	. Reduction of dinitronaphtalene.
	$C^6H^8N^2$	. Reduction of dinitrobenzine.
	$C^{19}H^{21}NO^3$	. "*Bebeeru*," a species of *Nectandra*, British Guiana.
	$C^{12}H^{12}N^2$	. Reducing agents on azobenzide and on azoxibenzide.
	$C^{21}H^{19}NO^5$	. *Berberis vulgaris.*
	$C^{23}H^{26}N^2O^4$	. *Strychnos nux vomica, S. Ignatii, S. Colubrina.*
	$C^{25}H^{30}N^2O^4.$	
	$C^8H^{10}N^4O^2$	. Tea, coffee, &c.
MINE.)		
NE.)		
	$C^{19}H^{17}ON^3$	. Dichloride of carbon on phenylamine.
	$C^5H^{10}N^2S^2$	. Sulphocarbonic anhydride on aldehydammonia.
	$C^{48}H^{99}N.$	
	$C^{20}H^{19}N^3O^3$	. *Chelidonium majus.*
	$C^{20}H^{24}N^2O$	. Isomeric transformation of cinchonine or of cinchonidine.
	$C^{20}H^{24}N^2O$	. Cinchona bark.
	$C^{21}H^{26}N^2O.$	
	$C^{20}H^{24}N^2O$	. Cinchona bark.
	$C^{21}H^{26}N^2O.$	
	$C^{18}H^{21}NO^3$	. Opium.
	$C^{20}H^{25}NO^3.$	

Name.	Formula.	Source or Mode of Formation.
Colchiceine	$C^{34}H^{44}N^2O^{11}$	*Colchicum autumnale.*
Collidine	$C^8H^{11}N$	Bone-oil.
Conhydrine	$C^8H^{17}NO$	Hemlock (*Conium maculatum*).
Conine	$C^8H^{15}N$	Hemlock (*Conium maculatum*).
Ethylconine	$C^{10}H^{19}N$.	
Methylconine	$C^9H^{17}N$.	
Cotarnine	$C^{12}H^{13}NO^3$ *	Oxidation of narcotine.
Coumaramine	$C^9H^7NO^2$	Reduction of nitro-coumarine.
Creatine	$C^4H^9N^3O^2$	Juice of flesh.
Creatinine	$C^4H^7N^3O$	Action of acids on creatine.
Cryptidine	$C^{11}H^{11}N$	Coal-tar.
Cumidine	$C^9H^{13}N$	Reduction of nitro-cumine.
Cyanamide	CH^2N^2	Gaseous chlor. of cyanogen on ammonia.
Amylcyanamide	$C^6H^{12}N^2$.	
Diamylcyanamide	$C^{11}H^{22}N^2$.	
Diethylcyanamide	$C^5H^{10}N^2$.	
Ethylcyanamide	$C^3H^6N^2$.	
Methylcyanamide	$C^2H^4N^2$.	
Methylethylcyanamide	$C^4H^8N^2$.	
Cyanethine	$C^9H^{15}N^3$	Potassium on cyanide of ethyl.
Cyanetholine	C^3H^5NO	Chloride of cyanogen on ethylate of sodium.
Cyaniline	$C^{14}H^{14}N^4$	Do. on phenylamine (aniline.)
Cyanocumidine	$C^{20}H^{26}N^4$	Do. on cumidine.
Cyanomelamine	$C^{15}H^{13}N^5$	Do. on melaniline.
Cyanotoludine	$C^{16}H^{18}N^4$	Do. on toluidine.
Diphenine	$C^{12}H^{12}N^4$	Reduction of dinitrazobenzide.
Diphenylformyldiamine	$C^{13}H^{12}N^2$	Chloroform on phenylamine.
Ethylamine	C^2H^7N.	
Diethylamine	$C^4H^{11}N$.	
Triethylamine	$C^6H^{15}N$.	
Ethylenamine	$C^2H^8N^2$	Bromide of ethylene on ammonia.
Diethylenamine	$C^4H^{10}N^2$	
Phenylethylenamine	C^8H^9N .	Bromide of ethylene on phenylamine.
(or Diphenyldiethylenamine	$C^{16}H^{18}N^2$?	
Triethylenamine	$C^6H^{12}N^2$	Bromide of ethylene on ammonia.
Flavine	$C^{13}H^{12}N^2O$	Reduction of binitrobenzophenone.
Furfurine	$C^{15}H^{12}N^2O^3$	Furfuramide boiled with potash.
Glycocoll	$C^2H^5NO^2$	Ammonia on chlor- or bromacetic-acid.
Glycosine	$C^6H^6N^4$	Ammonia on glyoxal.
Glyoxaline	$C^3H^4N^2$	
Guanine	$C^5H^5N^5O$	Guano, &c.
Harmaline	$C^{13}H^{14}N^2O$	Seeds of *Peganum Harmala.*
Hydrocyanharmaline	$C^{14}H^{15}N^3O$	Hydrocyanic acid and harmaline.
Harmine	$C^{13}H^{12}N^2O$	Seeds of *Peganum Harmala*; also oxidation of harmaline.
Hexylamine.		
Trihexylamine	$C^{18}H^{39}N$	Sulphite of œnanthylsodium distilled with lime.
? Jervine	$C^{30}H^{46}N^2O^3$	*Veratrum album*, white hellebore.
Lepidine	$C^{10}H^9N$	Coal-tar; also quinine and cinchonine distilled with potash.
Leucine	$C^6H^{13}NO^2$	Hydrochloric and hydrocyanic acids in valeral ammonia.
Lophine	$C^{21}H^{16}N^2$	Distillation of hydrobenzamide.
Lutidine	C^7H^9N .	Bone-oil.
Melamine	$C^3H^6N^6$	Action of heat on cyanamide.

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* According to unpublished analyses by Matthiessen and Foster.

Formula.	Source or Mode of Formation.
$C^{13}H^{13}N^3$	. Cyananilide (cyanophenylamine) and phenylamine.
$C^{21}H^{17}N^3$	. Chloride of cyanogen on naphtylamine.
CH^5N.	
C^2H^7N.	
C^3H^9N.	
$C^2H^7N^3$.	. Creatine or creatinine heated with oxide of mercury.
$C^{15}H^{17}N^3$	. Chloride of cyanogen on toluidine.
$C^{17}H^{19}NO^3$	. Opium.
$C^{19}H^{23}NO^3$.	
$C^{18}H^{21}NO^3$.	
$C^{10}H^9N$	. Reduction of nitronaphtylene.
$C^{12}H^{13}N$.	
$C^{24}H^{29}NO^9$	Opium.
$C^{22}H^{23}NO^7$*	
$C^{10}H^{14}N^2$ or C^5H^7N	. Tobacco.
$C^{10}H^8N^2O$	. Reduction of dinitronaphtylene.
$C^8H^{19}N$	.
$C^{20}H^{21}NO^4$	. Opium.
$C^9H^{13}N$	. Distillat. of bituminous shale of Dorsetshire.
$C^{18}H^{21}NO^3$	. *Cissampelos pareira*, L. (Antilles).
C^6H^7N.	. Reduction of nitrobenzene, &c.
$C^{11}H^{17}N$.	
$C^{16}H^{27}N$.	
$C^{10}H^{15}N$.	
$C^{38}H^{71}N$.	
$C^{22}H^{39}N$.	
$C^{13}H^{21}N$.	
$C^8H^{11}N$.	
$C^{12}H^{19}N$.	
$C^9H^{13}N$.	
C^7H^9N.	
$C^{18}H^{15}N$	. Sulphite of cinnamyl-ammonium distilled with lime.
C^8H^9N. or $C^{16}H^{18}N^2$	
C^8H^9N .	. Reduction of nitrophtalene.
C^6H^7N .	. Coal-tar.
$C^5H^{11}N$	. Piperine distilled with potash.
$C^{10}H^{21}N$.	
$C^7H^{15}N$.	
$C^6H^{13}N$.	
$C^{34}H^{38}N^2O^6$	. Pepper (*Piper nigrum*, *P. longum*).
RE.)	
C^5H^5N .	. Bone-oil.
$C^{20}H^{24}N^2O^2$	. Isomeric transformation of quinine, or of quinidine.
$C^{20}H^{24}N^2O^2$	. Cinchona bark.
$C^{20}H^{24}N^2O^2$	
$C^{22}H^{28}N^2O^2$.	
$C^{21}H^{26}N^2O^2$.	
C^9H^7N .	. Quinine or Cinchonine distil. with potash.
$C^{14}H^{17}N$.	
$C^{11}H^{11}N$.	
$C^{10}H^9N$.	

published analyses by Matthiessen and Foster

Name.	Formula.	Source or Mode of Formation.
Sarcine	$C^{5}H^{4}N^{4}O$	Juice of flesh.
Sarcosine	$C^{3}H^{7}NO^{2}$	Baryta-water on creatine.
Sinamine	$C^{4}H^{6}N^{2}$	Oxide of mercury on thiosinamine.
Ethylsinamine	$C^{6}H^{10}N^{2}$	Ethylthiosinamine heated with hydrate of lead.
Sinapine	$C^{16}H^{23}NO^{5}$	White mustard.
Sinapoline	$C^{7}H^{12}N^{2}O$	Hydrate of lead in oil of mustard (sulphocyanate of allyl).
Sincaline	$C^{5}H^{13}NO$	Alkalis on sinapine.
Sparteine	$C^{8}H^{13}N$	*Spartium scoparium*, *L.* (*Cytisus scoparius*, Linck.)
Strychnine	$C^{21}H^{22}N^{2}O^{2}$	*Strychnos nux vomica*, *S. Ignatii*, *S. colubrina.*
Tetrylamine (Petinine)	$C^{4}H^{11}N$	Bone-oil.
Thebaine	$C^{19}H^{21}NO^{3}$	Opium.
Theine. (See CAFFEINE.)		
Theobromine	$C^{7}H^{8}N^{4}O^{2}$	Cacao-beans.
? Thiacetonine	$C^{9}H^{18}NS^{2}$	Ammonia and hydrosulphuric acid on acetone.
Thialdine	$C^{6}H^{13}NS^{2}$	Hydrosulphuric acid on aldehydammonia.
Thiosinamine	$C^{4}H^{8}N^{2}S$	Ammonia on sulphocyanate of allyl (oil of mustard.)
Ethylthiosinamine	$C^{6}H^{12}N^{2}S$	Ethylamine on sulphocyanate of allyl.
Toluidine	$C^{7}H^{9}N$	Reduction of nitrotoluene.
Diethyltoluidine	$C^{11}H^{17}N.$	
Ethyltoluidine	$C^{9}H^{13}N.$	
Tritylamine	$C^{3}H^{9}N.$	
Urea (Carbamide)	$CH^{4}N^{2}O.$	
Allylurea	$C^{4}H^{8}N^{2}O.$	
Amylurea	$C^{6}H^{14}N^{2}O.$	
Diallylurea. (See SINAPOLINE.)		
Diethylurea	$C^{5}H^{12}N^{2}O.$	
Diphenylurea. (See FLAVINE.)		
Ethylallylurea	$C^{6}H^{12}N^{2}O.$	
Ethylamylurea	$C^{8}H^{18}N^{2}O.$	
Ethylpiperylurea	$C^{8}H^{16}N^{2}O.$	
Ethylurea	$C^{3}H^{8}N^{2}O.$	
Methylethylurea	$C^{4}H^{10}N^{2}O.$	
Methylpiperylurea	$C^{7}H^{14}N^{2}O.$	
Methylurea	$C^{2}H^{6}N^{2}O.$	
Naphtylurea	$C^{11}H^{10}N^{2}O.$	
Phenylallylurea	$C^{10}H^{12}N^{2}O.$	
Phenylurea	$C^{7}H^{8}N^{2}O.$	
Piperylurea	$C^{6}H^{12}N^{2}O.$	
Sulphallylurea. (See THIOSINAMINE).		
Tolylurea	$C^{8}H^{10}N^{2}O.$	
Valeraldine	$C^{15}H^{31}NS^{3}$	Hydrosulphuric acid on valeral ammonia.
Veratrine	$C^{32}H^{52}N^{2}O$	*Veratrum album.*
?Vinylamine	$C^{2}H^{5}N$	Chloride of ethylene on ammonia.

2. Alkaloids comparable to hydrate of ammonium, forming salts by combining with acids and eliminating water.

Name.	Formula.
Amylium.	
Hydrate of Methyldiethylamylium	$C^{10}H^{25}NO.$
" Tetramylium	$C^{20}H^{45}NO.$
" Triethylamylium	$C^{11}H^{27}NO.$
Brucium.	
Hydrate of Ethylbrucium	$C^{25}H^{32}N^{2}O^{5}.$

	Formula.
um	$C^{12}H^{25}NO$.
lconium	$C^{11}H^{23}NO$.
hylenium	$C^{5}H^{15}NO$.
hylium	$C^{7}H^{19}NO$.
n	$C^{8}H^{21}NO$.
lium	$C^{4}H^{13}NO$.
um	$C^{7}H^{13}NO$.
ium	$C^{8}H^{11}NO$.
nylium	$C^{20}H^{21}NO$.
lamylophenylium	$C^{14}H^{25}NO$.
nylium	$C^{12}H^{21}NO$.
ylium	$C^{9}H^{21}NO$.
ne	$C^{7}H^{11}NO$.
nium	$C^{28}H^{34}N^{2}O^{3}$.
nium	$C^{22}H^{28}N^{2}O^{3}$.
lium	$C^{13}H^{23}NO$.

ot included in the above list, such as acetamide, c., which possess the most important properties of xtent as some of the bodies there enumerated, but are associated with other well defined groups of com- seldom classed among alkaloids. On the other hand, ch as urea and its derivatives, which also find their had long been regarded solely as alkaloids before ds were discovered. This inconsistency is unavoidable. distinction between alkaloids and other substances; articular bodies ought, or ought not, to be classed as cide by reference to customary usage, or other circum- . F.

n chemico-legal investigations. — The certain ids in chemico-legal investigations involves their sepa- the substances with which they are mixed. When, quantity of an alkaloid is contained in a large quan- f animal or vegetable matter, its accurate separation lifficulty. The first chemist who gave a systematic ses was Stas (Bulletin de l'Académie Royale de Méde- ; Ann. Ch. Pharm. lxxxiv. 379; J. Pharm. Chim. xxii. e proposed continues to be the one most generally s in the successive and systematic use of various cohol, and ether.

is as follows: When an alkaloid has to be sought for nach or intestines, the substances to be examined are of pure absolute alcohol, to which from 0·5 gramme to acid (the former is preferable) have been added, and to between 70° and 75° C. (When an entire organ, , has to be examined for an alkaloid, it must first be n moistened with pure absolute alcohol, squeezed, and l till all the soluble constituents are removed. The n the same way as a mixture of suspected matter and mixture is filtered, the insoluble part washed with lic solution evaporated either in vacuo, or in a rapid not exceeding 35° C.

ting the alcohol contains fat or other insoluble matter, it must be filtered again through a filter wetted with distilled water, the filtrate must be evaporated nearly to dryness in vacuo over sulphuric acid, and the residue exhausted with cold absolute alcohol. The alcoholic solution is once more evaporated at the atmospheric temperature, either in the air, or better in vacuo, and the acid residue of this evaporation is dissolved in the *smallest possible* quantity of water. To the solution so obtained, pure, powdered acid carbonate of potassium or of sodium is added *very gradually* until there is no more effervescence. The neutralised solution is shaken with from four to five times its bulk of *pure* ether, and then allowed to settle. When the layer of ether has become perfectly clear, a little of it is decanted into a glass capsule, and left to spontaneous evaporation in a very dry place. If, after the evaporation of the ether, slight streaks of liquid appear on the side of the capsule, and run together slowly to the bottom of it, a liquid and volatile alkaloid is probably present. If this be the case, the warmth of the hand will be sufficient to cause the contents of the capsule to exhale a disagreeable smell which, according to the nature of the alkaloid, is more or less sharp, choking, and irritating. If these indications are wanting, the alkaloid, if any is present, is probably solid and non-volatile. According to the nature of the alkaloid, as indicated by this preliminary trial, Stas recommends different processes for its further purification.

A. *The alkaloid is liquid and volatile.* — In this case 1 or 2 cub. cent. of strong solution of caustic potash or soda are added to the contents of the flask, from which the small quantity of the ethereal solution was taken, and the whole is again well shaken. After standing for a sufficient time, the ether is poured off, and the residue is again shaken three or four times with fresh quantities of ether. The ethereal liquids so obtained, containing the alkaloid in solution, are united and shaken with 1 or 2 cub. cent. of a mixture of 4 parts by weight of water and 1 part of sulphuric acid; after being allowed to stand, the ether is poured off, and the acid liquid is washed with a second quantity of ether.

As the sulphates of the volatile alkaloids are soluble in water, but almost all insoluble in ether, the alkaloid sought is contained in the dilute sulphuric acid, in the form of pure sulphate *, while the animal matter which the ether may have taken up from the alkaline liquid together with the alkaloid, remains still dissolved by it.

In order to obtain the alkaloid from the solution of its sulphate, the latter is mixed with a strong solution of caustic potash or soda; the mixture is well shaken, and then exhausted with pure ether, which dissolves the alkaloid together with ammonia. The ethereal solution is allowed to evaporate † at as low a temperature as possible, and in order to remove from the residue the last traces of ammonia, the vessel containing it is placed for an instant in vacuo over sulphuric acid. The alkaloid then remains in a state of purity, with its characteristic chemical and physical properties.

B. *The alkaloid is solid and fixed.* — If on evaporating a small quantity of the ether with which the liquid neutralised by acid carbonate of sodium has been mixed (see above), there is no sign of the presence of a volatile alkaloid, the liquid must be further examined for fixed alkaloids as follows. Caustic potash or soda is put into the flask containing ether and the neutralised solution, the mixture is again vigorously shaken, the ethereal layer is poured off as soon as it is clear, and the watery alkaline liquid is several times washed with a considerable quantity of fresh ether. The ether now contains the free alkaloid in solution ‡, and on evaporation leaves either a solid residue or a colourless milky liquid containing solid particles in suspension. The smell of this residue is disagreeably animal, but not sharp; it colours red litmus-paper permanently blue.

In order to obtain the alkaloid in the crystalline state, a few drops of alcohol are poured into the capsule containing it and allowed to evaporate. Usually, however, it is still too impure to crystallise in this way. When this is the case, a few drops of water made very slightly acid by sulphuric acid, are poured upon the residue left by the evaporation of the alcohol, and made to come in contact with the whole of it by properly inclining the capsule in various directions: the alkaloid is thus dissolved, while the fatty impurities remain adhering to the capsule. The acid solution, which, if the last operation has been well performed, is clear and colourless, is poured off, the capsule is washed with a few drops more of the acid water, the washings are mixed with the first solution, and the whole is evaporated over sulphuric acid to about three quarters of its bulk. A saturated solution of pure carbonate of potassium uid, and the mixture is treated with absolute alcohol, ed alkaloid, but leaves undissolved the sulphate and um. On evaporating the alcoholic solution, the alkaloid n a state to show its characteristic reactions.

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* Sulphate of *conine* being not quite insoluble in ether, a little of this alkaloid may remain in the ethereal solution; the greater part, however, is always in the aqueous acid solution.

† If *conine* be present, a great part of it will evaporate with the ether.

‡ If *morphine* has to be sought for the liquid should be shaken with ether *immediately* after being neutralised with carbonate of sodium, and the ether should be poured off as quickly as possible, for, if the alkaloid have time to separate in the crystalline form, scarcely any of it is dissolved by the ether. (Otto.)

Ch. Pharm. c. 39) the above process of purifying the ageously modified as follows. Instead of decomposing by acid carbonate of potassium or sodium, and obtain- kaloid in ether, as described in the first part of this small quantity of water is washed with ether, as long as d leaves a residue on evaporation, and *afterwards* the rbonate of sodium and ether added to dissolve the On evaporating the ethereal solution thus prepared, of great purity. Or, the acid sulphate of the alka- ed with ether, as in the process for purifying a volatile

g and separating the organic alkaloids from mixtures of iven by Sonnenschein (Ann. Ch. Pharm. civ. 45). the property which the alkaloids possess, in common ecipitates in an acid solution of *phosphomolybdate* of ecution, and seems to give very accurate results.

um is thus prepared. The yellow precipitate obtained nolybdate of ammonium and phosphate of sodium is ater, and heated with carbonate of sodium till it is olution is evaporated to dryness, and the residue ignited if any reduction of molybdic acid take place during oistened with nitric acid and again ignited. It is then added till the solution has a strongly acid reaction, thus obtained is diluted till 10 parts of the solution ne. It must be carefully preserved from contact with

he separation of the alkaloids in the following manner. tter to be examined is repeatedly exhausted with very extract is evaporated at a heat of 30° C. to the consis- iluted, and left for some hours in a cool place before cipitated by excess of phosphomolybdic acid, the precipi- oughly washed with water containing phosphomolybdic ed while moist into a flask. Caustic baryta is added, : and the flask having been fitted with a delivery- a bulb-apparatus containing hydrochloric acid, heat is ammonia and volatile organic bases distil over, and are acid. The residue in the flask (containing the non- from excess of baryta by a current of carbonic anhy- to dryness, and extracted with strong alcohol. On olution, the bases are commonly obtained in a state at once exhibit their characteristic reactions: occa- re to be further purified by recrystallisation from alcohol

ed by Graham and Hofmann (Chem. Soc. Qu. J. v. ii. 39; Pharm. J. Trans. xi. 504) for the detection of ght doubtless be employed with equal advantage for the large quantities of liquid. It consists in leaving the ntact with about a fortieth of its weight of good animal being frequently shaken, collecting the charcoal on a e with water, and then boiling it for half an hour with t the alkaloid. The alcoholic solution is evaporated, by the addition of a few drops of potash or soda, and hich, when poured off and evaporated, leaves the organic roperties.

n. cix. 177) has indicated the acid liquid obtained by timony into aqueous phosphoric acid as a very delicate and as a substance which may probably serve for the general.

n separated in a state of purity by one of the above ts chemical and physical properties must be carefully ne its individual character, and the reactions obtained olled by comparison with those given by a pure speci- ed.

From what has been stated above relative to the absorption of the alkaloids by animal charcoal, it is evident that that substance should never be employed to decolorise a solution previous to its being examined for poisonous organic bases. The employment of basic acetate of lead for the same purpose should also be avoided, since it not only introduces a poisonous metal into the substance to be examined, but the sulphuretted hydrogen, which is required to remove the lead, is apt to combine with some of the organic matters present, forming compounds which, in contact with the air, give rise to highly coloured and disagreeably smelling products, very difficult afterwards to get rid of. (Stas.)

For further details concerning modifications of Stas's process, and for some methods which are not mentioned in this article, the reader is referred to the article on the same subject in Liebig, Poggendorff, and Wöhler's "Handwörterbuch der reinen und angewandten Chemie," 2nd edition, i. 464; and for the reactions of the individual alkaloids, to the various articles in this Dictionary in which they are specially described.—G. C. F.

ALKANET. The commercial name of two different plants. *True alkanet* consists of the leaves and roots of the *Lawsonia inermis*, which grows wild in the Levant. The leaves pulverised and made into a paste with water yield a yellow dye. The root, which contains a red pigment, is used as a cosmetic.

False alkanet (*Orcanette*, *Radix alcannæ spuriæ*) is the root of *Anchusa tinctoria*, which grows in France, Spain, Italy, Hungary and Greece. It is inodorous, has a faint, somewhat astringent taste, and colours the saliva. It is used in dyeing to produce a very brilliant violet and a grey; and for this purpose, linen or cotton goods previously prepared with alum-mordants for violet, and with iron-mordants for grey, are dipped in an alcoholic extract of the root. It is also used for dyeing silk, but not for wool. The colouring matter is called *Anchusin* (which see).

ALKARGEN and **ALKARSIN.** (See Arsenides of Methyl.)

ALLAGITE. A mineral which appears to be an intimate mixture of hornstone and silicate of manganese, perhaps also with carbonate of manganese.

ALLALITE. Syn. of Diopside and Augite.

ALLANITE. (See Orthite.)

ALLANTOIC and **AMNIOTIC LIQUIDS.** The fœtus of most mammiferous animals is enveloped in two membranes, the outer of which is called the *allantois*, and the inner the *amnium*. The space between the two is connected by a duct with the urinary bladder of the fœtus, and contains a liquid called the allantoic liquid, which is in fact the urine of the fœtus. The amnium at first lies close upon the fœtus, but gradually separates and becomes filled with a liquid in which the fœtus floats suspended by the umbilical cord. This liquor is the *liquor amnii*.

The allantoic liquid is especially distinguished by containing allantoin, together with albumin, alkaline lactates, chloride of sodium and phosphates, and sometimes glucose. The amniotic liquid contains albumin, pyin, a substance resembling mucus, extractive matter, and in some instances glucose, together with alkaline chlorides, sulphates and phosphates.

These liquids have been investigated by many distinguished chemists, but the most exact analyses of them are those which have been recently made by Schlossberger (Ann. Ch. Pharm. xcvi. 67, and ciii. 193), and by Majewski (Dissert. de Substantiarum, &c., Dorpat, 1858; J. pr. Chem. lxxvi. 99) Majewski's results are as follows:

Both liquids, in the earlier stages of development of the embryo of cows and sheep, are clear and colourless: at a later stage, the amniotic liquid of the cow becomes gummy and yellowish, also turbid; in sheep and swine on the contrary, it always remains clear and colourless, and never becomes gummy. The allantoic liquid becomes yellower with age, and at last reddish yellow, but remains clear, excepting in swine, in which it is always turbid. Both liquids generally exhibit an alkaline reaction.

In both liquids, the solid constituents, organic and inorganic, increase for the most part in quantity as the development of the fœtus progresses. In the human fœtus, however, the quantity of solid matter in the amniotic liquid decreases considerably towards the time of birth (see table). The same result was obtained by Vogt and by Scherer, the latter of whom found 2·416 per cent. of solid constituents in the amniotic liquid in the fifth month of gestation, and only 0·852 at birth.

The amniotic liquid retains its albumin up to the period of maturity of the fœtus. but (as appears from investigations on the human embryo) this amount decreases in the later period of the development of the embryo, and this diminution appears to be

he placenta. In the amniotic liquid of the cow, the
ordinary properties in the earlier stages of develop-
becomes gummy and no longer exhibits the usual
me result was obtained by Schlossberger, (p. 130).
in quantity and consistence as the development of
s clear (excepting in swine) and resembles saturated
rine contains iron and a peculiar compound of lime

f sugar gradually increases from the earliest period
rt time before birth. Sugar appears however to be
eders: in human embryonic liquids it cannot be

increases as development advances. Both liquids
d sulphates, the quantity being greater in the
id.
summary of the quantitative results obtained by

In 100 parts.

Spec. grav.	Water.	Solid sub-stance.	Or-ganic.	Inor-ganic.	Albu-min.	Sugar.	Urea.	P^2O^5	SO^3
1·0029	99·357	0·643	0·459	0·184		0·213			
1·0018 1·0065	99·460 98·980	0·540 1·020	0·400 0·650	0·140 0·370	0·105	0·063 0·241	0·20 0·40	0·0047	0·0052
1·0017 1·0082	98·945 98·127	1·055 1·873	0·685 1·198	0·370 0·675	0 125	0·114 0·449	0·302 0·500	0·0078 0·0356	0·0061 0·0069
1·0069 1·0100	98·515 97·453	1·485 2·547	0·917 1·671	0·568 0·876	0·170	0·172 0·642	0·370 0·606	0·0148 0·0137	0·0034 0·0175
1·0064 1·0097	98·660 97·380	1·349 2·620	0·905 0·960	0·435 0·660	0·241	0·196 0·667	0·475 0·780	0·0827 0·0898	0·006 0·0326
1·0047 1·0102	98·970 97·310	1·03 2·69	0·600 1·800	0·430 0·890	0·052	0·104 0·555	0·200 0·330	0·018 0·060	0·039 0·033
1·0064 1·0125	98·554 98·858	1·446 3·142	0·876 2·338	0·570 0·804	0·097	0·191 0·605	0·298 0·645	0·051 0·022	0·022 0·097
1·0075 1·0163	98·076 96·160	1·924 3·840	1·171 2·767	0·753 1·073	0·215	0·302 0·642	0·426 0·857	0·016 0·038	0·022 0·112
1·0049	95·405 98·490	3·595 1·510	0·95	5·600	2·288 0·357	none none	0·380		
1·0064 1·0088	98·114 97·580	1·886 2·420	1·248 1·705	0·638 0·715	0·562	trace trace	0·240 0·358		

oryonic liquid of cows the following quantities of
ages of the fœtus were: of (*a*) 30 weeks; (*b*) 18
eeks; (*e*) 5 weeks, and (*f*) 3 weeks:

Ash.	Soluble Salts.	Insoluble Salts.
0·72	0·694	0·026
1·02	1·00	0·02
0·89	0·86	0·03
0·93	0·91	0·02
0·73	0·70	0·03
0·71		

ate, exhibited an alkaline reaction, and effervesced
xhibited the reactions of sugar, the amniotic liquid
that substance, and the allantoic liquid of the same,
l not find urea in the amniotic liquid.
of both liquids exhibited differences of character
unusual reactions, indicating the presence of com-
bumin casein, mucus and pyin. The reactions ob-
in the following table:

	Amniotic liquid of *a* and *c*.	Allantoic liquid of *b* and *c*.
Appearance. Reaction on boiling and on addition of acetic acid.	*a*. Viscid like white of egg: mixed easily with water, and filtered readily. On boiling, became more mobile, with scarcely perceptible turbidity. On neutralising with acetic acid: scarcely perceptible turbidity, the liquid remaining viscid. On boiling, small flocks separated. The greater part of the protein-substance remained dissolved. On evaporation: films. *b*. Not viscid. Remained perfectly clear when boiled, either alone or with acetic acid.	*b*. Not viscid; clear on boiling. Acetic acid produces slight turbidity, and redissolves the flocks but slowly, even in excess and at the boiling heat. *c*. Coagulates even when boiled alone, the coagulum being but partially soluble in acetic acid. On evaporation: films. Both *b* and *c* become very turbid when boiled with chloride of calcium or sulphate of magnesium, especially *c*. The turbidity (arising in *b* most probably from carbonates) disappears on adding acetic acid.
Alcohol.	*a*. Throws down flocks soluble in warm water. *c*. No change.	*b*. No change. *c*. Turbidity.
Nitric acid.	*a*. Slight turbidity, disappearing with excess of acid. *c*. No turbidity. Liquid does not become yellow on boiling.	*b*. Scarcely perceptible turbidity. *c*. Precipitate and yellow colour on boiling.
HgCl.	*a*. Slight turbidity: small flakes on boiling. *c*. Turbidity. (With NO^3Hg: copious precipitate).	*b*. No change. *c*. Precipitate.
Ferrocyanide of potassium.	*a*. No change. *c*. Turbidity only after addition of acetic acid.	*b*. No change. *c*. After acidulation: flocks.
Acetate of lead. Basic acetate of lead. Tannin.	Copious precipitates.	Copious precipitates.
Alum.	No change in any instance.	

ALLANTOIN. $C^4H^6N^4O^3$, or $C^8H^6N^4O^6$.—Discovered by Vauquelin and Buniva (Ann. Chim. xxxiii. 269) in the amniotic liquid of the cow.* Lassaigne (Ann. Ch. Phys. [2] xvii. 301) obtained it from the allantoic liquid of the cow, and Wöhler (Ann. Ch. Pharm. lxx. 220) from the urine of calves. It is formed artificially by treating uric acid with water and peroxide of lead. (Liebig and Wöhler. Ann. Ch. Pharm. xxvi. 244.)

$$\underbrace{C^5H^4N^4O^3}_{\text{Uric acid.}} + H^2O + 2PbO = \underbrace{C^4H^6N^4O^3}_{\text{Allantoin.}} + \underbrace{CPb^2O^3}_{\text{Carbonate of lead.}};$$

or with a mixture of ferricyanide of potassium and caustic potash. (Schlieper, Ann. Ch. Pharm. lxvii. 216.)

$$\underbrace{C^5H^4N^4O^3}_{\text{Uric acid.}} + \underbrace{2C^6N^6Fe^2K^6}_{\text{Ferricyanide of potassium.}} + 4KHO = \underbrace{C^4H^6N^4O^3}_{\text{Allantoin.}} + \underbrace{CK^2O^3}_{\text{Carbonate of potassium.}} + \underbrace{4C^6N^6FeK^4}_{\text{Ferrocyanide of potassium.}} + H^2O.$$

Preparation.—Pulverised uric acid is suspended in water, nearly at the boiling heat, and finely pounded oxide of lead is added by small portions, and with frequent stirring, till the last portions no longer turn white. The liquid filtered while hot deposits on

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* As, however, subsequent experimenters have not been able to obtain it from that source, it is probable that the amniotic liquid was mixed with allantoic liquid.

hile urea remains in solution, and oxalate of lead is
er compounds are produced by the action of the excess
oin. (Liebig and Wöhler.)

$$b''O + H^2O = \underbrace{2CH^4N^2O}_{\text{Urea.}} + \underbrace{C^2Pb''O^4}_{\text{Oxalate of lead.}}$$

allantoic liquid, the liquid is evaporated to a fourth of
h are deposited on cooling are decolorised with ani-
ne, it is prepared by evaporating the liquid to a syrup,
l days, then diluting with water; washing the deposit
y of gelatinous matter, chiefly consisting of urate of
line residue of allantoin and phosphate of magnesium
filtering at the boiling heat; and adding a few drops
ate to retain in solution the small quantity of phos-
the boiling liquid. The allantoin is then deposited in

hining colourless prisms, having a vitreous aspect, and
r (Ann. Ch. Pharm. lxxi. 68), to the monoclinic system.
on on vegetable colours. It dissolves in 160 pts. of
boiling water. Alcohol dissolves it in larger quantity.
lation, allantoin is resolved into carbonate and cyanide
f empyreumatic oil and a very porous charcoal. When
rochloric acid, it is converted into urea and allanturic

$$+ H^2O = CH^4N^2O + \underbrace{C^3H^4N^2O^3}_{\text{Allanturic acid.}}$$

resolved into carbonic acid, carbonic oxide, and am-
)

$$3H^2O = 2CO^2 + 2CO + 4NH^3.$$

s off ammonia and precipitates oxalate of barium:

$$a''H^2O^2 + H^2O = 4NH^3 + 2C^2Ba''O^4.$$

(Liebig and Wöhler). A solution of allantoin in
ntoin unaltered, if immediately mixed with acids; but
changes spontaneously into *hydantoate of potassium*
nger precipitated by acids, gives off but little ammo-
rm any oxalic acid:

$$O^3 + KHO = C^4H^7KN^4O^4;$$

ali, the hydantoate of potassium is resolved into urea

$$O^4 = CH^4N^2O + C^3H^2KN^2O^3.$$

allantoin is boiled with *metallic oxides*, compounds
salts of allantoin. Some of them consist simply of
replaced by a metal; thus, the *cadmium*-compound is
ompound, obtained by mixing a solution of allantoin
with ammonia, is $C^4H^5AgN^4O^3$. But most of them
oxide; thus, the zinc-compound is $Zn''O.C^8H^{10}Zn''N^8O^6$,
$.C^8H^{10}PbN^8O^6$. These compounds are insoluble or
d decompose at 100° or a little above (Limpricht,
). The silver-compound was obtained by Liebig and

n is boiled with excess of mercuric oxide, the filtrate
after a while deposits an amorphous powder containing
$g''O.3C^8H^{10}N^8O^5$. Three other compounds are said to
uor. Allantoin does not precipitate corrosive sublimate;
a cold and very dilute solution, it forms a precipitate
O^6, or $5Hg''O.2C^8H^{10}N^4O^5$.

ded a method for the quantitative estimation of allan-
aduated solution of mercuric nitrate. The method is
the estimation of urea (*q. v.*), but is applicable to
only in liquids not containing urea. To precipitate
$H^6N^4O^3$, requires 172 grms. of mercuric oxide: conse-
ated solution of mercuric nitrate containing 0·770 grm.

mercuric oxide, will precipitate 0·448 grm. allantoin. The liquid should contain a considerable excess of the mercuric salt.

ALLANTURIC ACID. $C^3H^4N^2O^3$.—A product of the decomposition of allantoin under the influence of nitric acid, hydrochloric acid, or peroxide of lead (p. 131): also obtained by treating uric acid with nitric acid or chlorine. It is a white solid body, slightly acid, deliquescent, nearly insoluble in alcohol, and yields by distillation a product containing hydrocyanic acid, with a bulky residue of charcoal. With nitrate of silver and acetate of lead, it forms white bulky precipitates, soluble in excess of these salts, and of allanturic acid. (Pelouze, Ann. Ch. Phys. [3] vi. 71.)

ALLEMONTITE. Arsenide of Antimony. (p. 371.)

ALLITURIC ACID. $C^3H^3N^2O^3$? Obtained by mixing an aqueous solution of alloxantin with excess of hydrochloric acid, boiling the liquid rapidly down to a small quantity, treating the pulverulent mixture of alliturie acid and undecomposed alloxantin with nitric acid to dissolve out the latter, and dissolving the residue in 15 or 20 pts. of hot water. The solution on cooling deposits alliturie acid in the form of a bulky yellowish white powder. It dissolves in strong sulphuric acid, and is precipitated from the solution by water. Its solution in ammonia yields *alliturate of ammonium*, by spontaneous evaporation, in colourless shining needles. The acid is decomposed by boiling with potash, with evolution of ammonia. (Schlieper, Ann. Ch. Pharm. lvi. 20.)

ALLIUM SATIVUM. (*Garlic.*) 100 pts. of the ash of the fresh plant yield 0·54 p.c. ash, containing in 100 parts: 12·17 carbonic anhydride, 4·82 sulphuric anhydride, 2·18 phosphoric anhydride, 35·13 potash, a trace of soda, 2·75 chloride of sodium, 5·74 carbonate of calcium, 6·89 carbonate of magnesium, 30·09 basic phosphate of calcium, 0·22 silica, and traces of the phosphates of magnesium and iron.

ALLOCHROÏTE. A variety of garnet, fine-grained, massive, and of dark dingy colour. (See GARNET.)

ALLOGONITE. Syn. with HERDERITE.

ALLOMORPHITE. Breithaupt's name for a mineral from Rudolstadt, which, according to the analysis of Gerngross, appears to be merely sulphate of barium.

ALLOPHANE. A hydrated silicate of aluminium, of a blue and sometimes green or brown colour, occurring massive, or in imitative shapes, in a bed of iron-shot limestone, or greywacke slate in the forest of Thuringia. It is transparent or translucent on the edges, moderately hard, but very brittle. Fracture imperfectly conchoidal. Lustre vitreous. Specific gravity 1·89. According to Stromeyer's analysis, it contains 21·92 silver, 32·2 alumina, 3·06 ferric hydrate, 0·73 lime, 0·52 sulphate of calcium, 3·06 carbonate of copper, and 41·30 water. Bunsen found in a specimen from a bed of lignite near Bonn, nearly the same composition, with a slight admixture of the carbonates of calcium and magnesium, but no copper. The mineral appears from the analyses of Walchner, Berthier, Guillemin, and others, to vary considerably in composition, but irrespective of foreign admixtures it agrees nearly with the formula $Al^2O^3.3SiO^2 + 5H^2O$. Schnabel (Jahresber. d. Chem. 1850, s. 731), has, however, analysed several allophanes containing from 14 to 19 per cent. of oxide of copper.

ALLOPHANIC ACID. $C^2H^4N^2O^3 = \left.\begin{matrix}C^2H^3N^2O^2\\H\end{matrix}\right\}O$. *Ureo-carbonic acid.* (Gm. ix. 266; Gerh. i. 418.) By passing the vapour of cyanic acid into absolute alcohol, Liebig and Wöhler obtained in 1830 a peculiar ether, which they regarded as cyanate of ethyl; but in 1847 (Ann. Ch. Pharm. lix. 291), they discovered that the substance thus formed was the ether of a peculiar acid which they called allophanic acid.

This acid contains the elements of 2 at. cyanic acid and 1 at. water:

$$C^2H^4N^2O^3 = 2CHNO + H^2O.$$

Its ethers are produced when the vapour of cyanic acid comes in contact with the corresponding alcohols, and these ethers, treated with caustic alkalis, yield the corresponding salts of allophanic acid. The acid itself is not known in the separate state; when its salts are decomposed by a stronger acid, it is resolved into carbonic anhydride and urea:

$$C^2H^4N^2O^3 = CO^2 + CH^4N^2O.$$

In like manner the salts when heated in the state of aqueous solution, are resolved into carbonic anhydride, a carbonate, and urea.

Allophanate of Barium.—Obtained by dissolving allophanate of methyl or ethyl in baryta-water, whereby wood-spirit or alcohol is set free. The best method is to triturate allophanate of ethyl with crystals of hydrate of barium and baryta-water, without applying heat, till the ether disappears; filter from the remaining baryta-crystals; and

ays in a closed vessel; the barium-salt then separates
odules and crusts. The crystals are separated from
e liquid quickly decanted; any carbonate of barium
parated by elutriation; and the crystals are washed a
f cold water, and dried on paper at the temperature of

aline reaction. When heated alone, it does not
lves monocarbonate of ammonium, and leaves cyanate
n becomes turbid below 100° C., gives off carbonic
eposits all the baryta in the form of carbonate, and
urea in solution:

$$H^2O = CO^3Ba'' + CO^2 + 2CH^4N^2O.$$

ed upon it, is decomposed with brisk effervescence,
urea; even carbonic acid produces this decomposition,
cid nor ammonia is formed.
pared like the barium-salt. Crystallisable. Sparingly

solution of allophanic ether in alcoholic potash quickly
nbling those of chlorate of potassium.
ained like the potassium-salt, or by triturating the
of heat, with an equivalent quantity of aqueous sul-
hol upon the filtrate, which causes the sodium-salt to
aving an alkaline reaction. The aqueous solution of
in vacuo, leaves the salt in the form of an iridescent
ween 40° and 50° C. it leaves the salt partly unde-
rea and carbonate of sodium. The aqueous solution
f carbonic anhydride and deposits shining scales of
ecipitate chloride of barium, in the cold, but, when
ate precipitate of carbonate of barium.

compounds contain the elements of 2 at. cyanic acid,
ic, diatomic, or triatomic, *e. g.*

. . $C^4H^8N^2O^3 = 2CNHO + C^2H^6O$
. . $C^4H^8N^2O^4 = 2CNHO + C^2H^6O^2$
. . $C^5H^{10}N^2O^5 = 2CNHO + C^3H^8O^3$

the vapour of cyanic acid into the alcohols.

$I^{14}N^2O^3 = C^2H^3(C^5H^{11})NO^3$.—Amylic alcohol rapidly
the action of heat on cyanuric acid, the liquid, after
na of crystals, which may be purified by solution in
n. Ch. Pharm. lix. 23.)
reous scales, unctuous to the touch, and without taste
ld water, and its solution in hot water is neutral to
recipitate metallic salts. It is very soluble in alcohol
from the solutions by water. It is not attacked by
hydrosulphuric acid. It melts at a gentle heat, and
t its melting-point is very near that at which decom-
d above 100° C. it boils, gives off vapours of amylic al-
anuric acid, $3C^7H^{14}N^2O^3 = 3C^5H^{12}O + 2C^3N^3H^3O^3$.
gives off amyl-alcohol (Schlieper). According to
hot potash-ley converts it into carbonate of potassium,

$$O = 2CO^3K^2 + C^5H^{13}N + NH^3 + H^2O.$$

llophanic Ether, $C^4H^8N^2O^3 = C^2H^3(C^2H^5)N^2O^3$.—When
ted cyanuric acid are passed into absolute alcohol,
gradually deposits crystals of allophanic ether. The
antity of alcohol, then dissolved in a mixture of alcohol
se by evaporation (Liebig and Wöhler, Ann. Ch.
cording to Debus, allophanic ether is likewise produced
arbonate of ethylic disulphide.
colourless transparent needles, having a strong lustre.
dissolves in boiling water and in alcohol, sparingly in
al to test-papers, have no taste, and do not precipitate

ia somewhat more freely than in water, and crystallises therefrom, apparently free from ammonia. It dissolves in dilute sulphuric and nitric acid at the boiling heat, apparently without decomposition.

The crystals when heated in an open vessel melt and volatilise, the vapours condensing in the air in woolly flocks.

Treated with cold alcoholic potash or baryta-water, it yields a metallic allophanate and alcohol; with a boiling solution of potash, it forms cyanurate of potassium.

Allophanate of Ethylene, $C^4H^8N^2O^4 = \left.\begin{matrix}C^2H^3N^2O^2\\H.C^2H^4\end{matrix}\right\}O^2$. *Allophanate of Glycol.*—Glycol (hydrate of ethylene) absorbs cyanic acid vapour with considerable force, so that it is best to cool the liquid during the absorption. The product is a white mass which dissolves in boiling alcohol, and separates on cooling in colourless shining laminæ. It is soluble in water, and melts at 100° C. without decomposition, to a clear colourless liquid, which solidifies in the crystalline form on cooling. At a stronger heat, it gives off carbonate of ammonium, and a thick viscid liquid, while cyanuric acid remains behind. Strong acids decompose it. With hydrate of barium, it behaves like the glycerin-compound next to be described; also with alcoholic potash. Strong aqueous potash likewise decomposes it, without formation of cyanuric acid. (Baeyer, Ann. Ch. Pharm. cxiv. 160.)

Allophanate of Glyceryl, $C^5H^{10}N^2O^5 = \left.\begin{matrix}C^2H^3N^2O^2\\H^2.(C^3H^5)'''\end{matrix}\right\}O^3$. *Allophanate of Glycerin.*—Glycerin absorbs cyanic acid vapour, and is thereby converted into a white sticky mass, which dissolves in alcohol, leaving only a small quantity of cyamelide. The hot saturated solution, on cooling, deposits allophanate of glyceryl in hard crusts, composed of small translucent nodules. The crystallisation is often slow, especially when much glycerin is present; hence it is best to wash the crude product with cold alcohol before dissolving it in hot alcohol. The nodules, after recrystallisation from alcohol and drying at 100°, gave by analysis 33·6 per cent. carbon, 5·7 hydrogen, and 15·5 N, the formula requiring 33·7 C, 5·6 H, and 15·7 N.

Allophanate of glyceryl has neither taste nor smell, dissolves slowly but abundantly in water, and with tolerable facility in boiling alcohol. Heated in the dry state, it melts at about 160° C. to a colourless liquid, which solidifies in a gelatinous mass on cooling. On raising the temperature, a large quantity of carbonate of ammonium is evolved, and the mass ultimately turns brown and emits an odour of burnt horn.

It is not decomposed by *dilute acids* at ordinary temperatures, but strong nitric and sulphuric acids decompose it, with evolution of carbonic anhydride.

When triturated with water and *hydrate of barium*, it dissolves with facility; but the clear filtered solution deposits, after a short time, a bulky crystalline precipitate of carbonate of barium. The precipitation takes place even when the quantity of baryta is less than sufficient to saturate the allophanic acid present, so that it does not appear possible to prepare allophanate of barium in this manner. A certain quantity of that salt appears, however, to be formed, inasmuch as the liquid, after long standing, still deposits carbonate of barium when heated. If alcohol be added to the liquid containing an insufficient quantity of baryta, allophanate of ethyl is produced, probably by a catalytic action. Allophanate of glyceryl heated with baryta-water, yields nothing but carbonate of barium, urea, and glycerin.

In an alcoholic solution of *potash*, allophanate of glyceryl cakes together to a sticky mass, then gradually dissolves, the solution after a while depositing long needles which gradually change to small bulky masses of needles, apparently consisting of ethyl-carbonate of potassium. (Baeyer.)

Allophanate of Methyl, $C^3H^6N^2O^3 = C^2H^3(CH^3)N^2O^3$.—Discovered by Richardson in 1837 (Ann. Ch. Pharm. xxiii. 128), and originally called *ureo-carbonate of methyl*. When cyanic acid vapour is passed into methyl-alcohol, colourless crystals are obtained, which must be repeatedly washed with water, and then dried at 100° C. When heated, they partly volatilise undecomposed, and are partly resolved into ammonia, methylene gas (?), carbonic anhydride, and cyanuric acid:

$$3C^3H^6N^2O^3 = 3NH^3 + 3CH^2 + 3CO^2 + C^3H^3N^3O^3.$$

Heated with potash, they are decomposed in the same manner as the ethyl-compound. They dissolve readily in water, wood-spirit, and alcohol, especially when heated, forming neutral solutions.

Allophanate of Eugenic acid, $C^{12}H^{14}N^2O^4 = C^2H^3(C^{10}H^{11}O)N^2O^3$.—Eugenic acid rapidly absorbs cyanic acid vapour, forming a thick mass, which dissolves in hot alcohol and separates in long shining needles on cooling. At 100° C. it gave 57·0—57·9 per cent. C, 5·7—5·9 H, and 11·3 N (calc. 57·6 C, 5·6 H and 11·2 N). It contains the elements of 2 at. cyanic acid, and 1 at. eugenic acid ($2CNHO + C^{10}H^{12}O^2$), and is therefore analogous in composition to the allophanic ethers.

It is insoluble in water, sparingly soluble in cold alcohol, abundantly in hot alcohol.

crystallise, so that even small quantities of the solution
ly considerable length. It is very soluble in ether, is
as a silky lustre, and is permanent in the air.
Triturated with water and hydrate of barium, it forms
nate and allophanate of barium. Alcoholic potash does
allophanate of potassium. When heated, it is resolved
s. (Baeyer, Ann. Ch. Pharm. cxiv. 164.)

IERISM.

lride, Laurent.) $C^4H^2N^2O^4$.

317 by Brugnatelli, who designated it *Erythric acid:*
by Liebig and Wöhler, in 1838 (Ann. Ch. Pharm.
Schlieper (Ann. Ch. Pharm. lv. 253).

—Alloxan is one of the numerous products of the oxida-
ion is a matter of some nicety. Liebig and Wöhler
Mag. 1846), prepare it by the action of nitric acid on
acid specific gravity 1·4 to 1·42), must be employed, and
llowed to rise above from 30° to 35° C. The process is
parts strong nitric acid are placed in a beaker or por-
cold water, and 1 pt. uric acid is added in successive
tirring, care being taken not to add a fresh portion of
d by the addition of the former portion has quite sub-
d nitrogen are evolved with effervescence, the action
it as the operation proceeds; and crystals of alloxan
the decomposition is complete, the mixture is left over
crystalline magma is then thrown on a funnel plugged
led glass, and the last portions of the mother-liquor are
with ice-cold water, till the washings have only a faintly
mmends removing the alloxan as it forms, in order to
action of the nitric acid. The crystals of alloxan are
paper or a porous tile, and then purified by solution in
of water at from 60° to 80° C.; the solution is filtered,
by evaporating the mother-liquor at a heat not exceed-
obtained. The mother-liquor from these crystals, as
off, still contains alloxan, which is best separated by
o alloxantin. For this purpose, Schlieper proceeds as
iquors are *nearly* neutralised by carbonate of calcium or
n were complete, the alloxan would be converted into
e mixture are saturated with sulphuretted hydrogen,
n are precipitated, some dialuric acid being also formed
s. The remaining $\frac{1}{6}$ is then added, the alloxan in which
rmed into alloxantin. The alloxantin, which separates
reed from sulphur by solution in boiling water and crys-
ert it into alloxan, one half of it is boiled with twice its
eing added drop by drop until the evolution of nitric
whole is heated in a water-bath until effervescence has
remaining half are then added successively, until a fresh
ence, then a little nitric acid, and so on till the nitric
l, a little alloxantin remaining in excess. The solution
drops of nitric acid added to the filtrate, which deposits
The total weight of alloxan thus obtained, should be
d employed. It is not advisable to operate on more than
ce.

potassium to nitric acid as an oxidising agent. Into a
4 oz. of uric acid, and 240 grm. or 8 oz. of moderately
adds in successive portions, with constant stirring, 31
rate. Heat is evolved, which must not be allowed to
d a solution is obtained, containing only alloxan and
$= C^4H^2N^2O^4 + CH^4N^2O$). If proper care be taken, no
is diluted with twice its volume of cold water, and de-
any undissolved uric acid, which is heated to 50° with
id, and oxidised by a fresh portion of chlorate. In order
he urea, it is converted into alloxantin and reconverted
ove described.

e above methods contains 1 or 4 atoms of water of crys-
an is obtained by heating the monohydrated compound

to 150°—160° C. in a stream of dry hydrogen: the tetrahydrated compound must be first converted into the monohydrate by very careful heating to 100°. (Gmelin.)

Properties. — Anhydrous alloxan is of a pale reddish colour, which is probably due to the action of heat. When crystallised, it contains 1 or 4 atoms of water of crystallisation. The crystals obtained by evaporating a warm aqueous solution, contain 1 atom of water: they are oblique rhombic prisms, belonging to the monoclinic system, having the appearance of rhomboidal octahedra truncated at the extremities; they are large, transparent, and colourless, of a glassy lustre, and do not effloresce in the air. Liebig and Wöhler regarded this compound as anhydrous. Those obtained by cooling a warm saturated aqueous solution are transparent, pearly crystals, often an inch long, belonging to the trimetric system: they effloresce rapidly in warm air, and when heated to 100° are converted in the monohydrated compound. According to Gregory, there exists a third hydrate containing $2\frac{1}{2}$ atoms of water.

Alloxan is readily soluble in water or alcohol, forming colourless solutions, whence it may be precipitated by nitric acid. Its aqueous solution has an astringent taste, and colours the skin purple after a time, imparting a peculiar and disagreeable smell. It reddens litmus, but does not decompose alkaline-earthy carbonates: neither does it attack oxide of lead, even on boiling.

The following is the percentage composition of the three varieties:

C^4.	48	33·8
H^2.	2	1·41
N^2.	28	19·72
O^4.	63	45·07
$C^4H^2N^2O^4$.	142	100·00

		Calc.	Gm.
$C^4H^2N^2O^4$	142	88·75	88·65
H^2O	18	11·25	11·35
$C^4H^2N^2O^4 + aq.$	160	100·00	100·00

		Calc.	L. a. W.	Gm.
$C^4H^2N^2O^4 + H^2O$	160	74·77	73·5	74·72
$3H^2O$	54	25·23	26·5	25·28
$C^4H^2N^2O^4 + 4\ aq.$	214	100·00	100·0	100·00

Decompositions. — 1. *By Heat.* When heated, alloxan melts, and is decomposed, forming, besides other products, cyanide of ammonium and urea. (Handwb. d. Chem.)

2. *By Electrolysis.* — An aqueous solution of alloxan is decomposed by the voltaic current, oxygen being evolved at the positive pole, and crystals of alloxantin formed at the negative pole.

3. *By Nitric acid.* — Hot dilute nitric acid converts alloxan into parabanic acid and carbonic anhydride:

$$C^4H^2N^2O^4 + O = \underset{\text{Parabanic ac.}}{C^3H^2N^2O^3} + CO^2$$

Further action of nitric acid converts the parabanic acid into nitrate of urea and carbonic anhydride. Monohydrated alloxan is scarcely attacked by heating with strong nitric acid. (Schlieper.)

4. *By Hydrochloric and Sulphuric acids.* — When heated with these acids, alloxan is converted into alloxantin, which gradually separates, and the mother-liquor yields on evaporation acid oxalate of ammonium. The decomposition goes through several stages: first, alloxantin, oxalic and oxaluric acids are formed; then the oxaluric acid is decomposed into oxalic acid and urea; and the urea is finally resolved into carbonic anhydride and ammonia, which last combines with the oxalic acid. (Liebig and Wöhler.)

5. An aqueous solution of alloxan is decomposed by *boiling* into carbonic anhydride, parabanic acid, and alloxantin, which separating on cooling:

$$3C^4H^2N^2O^4 = CO^2 + \underbrace{C^3H^2N^2O^3}_{\text{Parabanic acid.}} + \underset{\text{Alloxantin.}}{C^8H^4N^4O^7}$$

6. *By reducing agents*, alloxan is converted into alloxantin. This decomposition is effected by protochloride of tin, sulphuretted hydrogen, or zinc and hydrochloric acid (nascent hydrogen):

$$2C^4H^2N^2O^4 + H^2 = C^8H^4N^4O^7 + H^2O$$

the further action of the two latter reagents converts the alloxantin into dialuric acid:

$$C^8H^4N^4O^7 + H^2 + H^2O = \underbrace{2C^4H^4N^2O^4}_{\text{Dialuric acid.}}$$

ed when an aqueous solution of alloxan is boiled with
n, however, aqueous alloxan is saturated with sul-
tion evaporated at a gentle heat, it yields on cooling
ugated acid, which, by analysis of its potassium-salt
of 1 atom alloxan and 1 atom sulphurous anhydride
rated solution of aqueous alloxan is treated with sul-
added, and the whole boiled, thionurate of ammonium

$$H^3 + SO^3H^2 = \underset{\text{Thionuric acid.}}{C^4H^5N^3SO^6} + H^2O$$

earths, alloxan is converted into alloxanic acid:

$$O^4 + H^2O = \underset{\text{Alloxanic acid.}}{C^4H^4N^2O^5}$$

a- or lime-water a gradual white precipitate of allox-
milar action is produced by a mixture of chloride of
ammonia. If the alkali be in excess, the precipitated
nd the filtrate contains urea (Schlieper). By boil-
is decomposed into mesoxalic acid and urea:

$$+ 2H^2O = \underset{\text{Mesoxalic acid.}}{C^3H^2O^5} + \underset{\text{Urea.}}{CH^4N^2O}$$

of alloxan in aqueous ammonia turns yellow when
ms a yellow transparent jelly of mycomelate of am-
lution alloxanate and mesoxalate of ammonium and

$$+ 2NH^3 = \underset{\text{Mycomelic acid.}}{C^4H^4N^4O^2} + 2H^2O$$

alloxan gives a deep blue colour, but no precipitate

heated with *peroxide of lead*, carbonic anhydride is
itated, and urea is contained in the solution:

$$+ H^2O = CH^4N^2O + 2CO^3Pb + CO^2.$$

radually added to a boiling solution of *neutral acetate*
ecipitated, and urea remains in solution. When the
an-solution, alloxantin and oxalic acid are formed.

F. T. C

$H^4N^2O^5$. = alloxan + H^2O.
ig and Wöhler, in 1838 (Ann. Ch. Pharm. xxvi. 292),
. (Ann. Ch. Pharm. lv. 263, lvi. 1.)
– Alloxanic acid is formed when alloxan is brought
alkalis (see ALLOXAN), alkaline carbonates, or acid
. It is prepared by decomposing alloxanate of barium
spended in a little water, and a slight excess of dilute
tant agitation: 5 pts. salt require 1½ pt. strong sul-
digestion for some time at a gentle heat, the excess
pure carbonate of lead, the excess of lead by sul-
ess of gas by heat: the solution is then filtered, and
er sulphuric acid in vacuo, or at a temperature not

alloxanic acid forms hard white needles, arranged in
ses: if it has been heated above 40° C. it crystallises
e crystals are permanent in the air: have a sour taste,
adily soluble in water, less readily, viz. in 5 to 6 pts.
e solution is acid to litmus, readily decomposes car-
ves zinc, cadmium, &c., with evolution of hydrogen.

48	30·0
4	2·5
28	17·5
80	50·0
160	100·0

It is a dibasic acid, forming acid as well as normal salts: the formula of normal alloxanates is $C^4H^2M^2N^2O^5$, of acid alloxanates, $C^4H^3MN^2O^5$. It also appears to form basic salts with some heavy metals. Alloxanates are mostly obtained by the action of aqueous alloxanic acid on metallic carbonates. The alkaline alloxanates are soluble in water: the normal salts of other metals are generally more or less insoluble, the acid salts readily soluble. They part with their water of crystallisation at temperatures varying from 100° C. to 150°; and require a stronger heat for their decomposition.

The alloxanates have been investigated principally by Schlieper (*loc. cit.*). The only one which requires special mention is the normal *barium-salt*, which is employed for the preparation of alloxanic acid. It is obtained by mixing 2 vols. of a cold saturated solution of alloxan with 3 vols. of a cold saturated solution of chloride of barium, heating the mixture to 60° or 70°, and adding gradually potash-solution, with constant agitation. Each addition of potash produces a white curdy precipitate, which soon redissolves: at last the precipitate remains permanent, and the liquid suddenly becomes filled with alloxanate of barium, which falls down as a heavy crystalline powder, and may be freed from chloride of potassium by washing with cold water. If too much potash has been added, a persistent curdy precipitate forms, consisting of basic alloxanate and mesoxalate of barium; it must be redissolved by the addition of a little alloxan-solution. A less abundant, but more certainly pure product is obtained by adding baryta-water to aqueous alloxanic acid.

Decompositions. 1. *By Heat.*—When heated, the acid melts with intumescence, becomes carbonised, and evolves vapours of cyanic acid. Alkaline alloxanates are decomposed by heat into a mixture of carbonate and cyanide. An aqueous solution of alloxanic acid is decomposed by boiling, carbonic anhydride being abundantly evolved, and two new bodies formed, one of which, *leucoturic acid*, being insoluble in water, separates as a white powder when the solution, after evaporation to a syrup, is diluted with water; while the other, *difluan*, remains in solution, but may be precipitated by alcohol. The latter is formed in far the larger quantity. The composition of these bodies is not accurately established: Schlieper assigns to the former the formula $C^3H^3N^2O^3$, to the latter, $C^3H^4N^2O^{3\frac{1}{2}}$ or $C^3H^4N^2O^4$. Schlieper states that a third substance is also formed, soluble in water and alcohol, with the formula $C^3H^3N^2O^3$. The alcoholic solution of alloxanic acid is not decomposed by boiling. Alloxanates are decomposed by boiling with water into mesoxalate and urea:

$$C^4H^4N^2O^5 + H^2O = C^3H^2O^5 + CH^4N^2O$$

2. When heated with nitric acid, alloxanic acid is decomposed into parabanic acid and carbonic anhydride:

$$C^4H^4N^2O^5 + O = C^3H^2N^2O^3 + CO^2 + H^2O.$$

3. Alloxanate of potassium gives a dark blue precipitate with ferrous-salts. (See Alloxan.)

Alloxanic acid is not decomposed by sulphuretted hydrogen, or by boiling with bichromate of potassium or tetrachloride of platinum.

According to Gmelin, the compound described by Vauquelin (Mém. du. Mus. vii. 253) by the names *acide purpurique blanc* or *urique suroxigenèe* (oxuric acid) is to be regarded as impure alloxanic acid. —F. T. C.

ALLOXANTIN. (*Uroxin.*) $C^8H^4N^4O^7 + 3H^2O$.

History.—Probably first noticed by Prout; first described by Liebig and Wöhler in 1838; further examined by Fritzsche, who called it *uroxin* (J. pr. Chem. xiv. 237).

Formation and preparation.—Alloxantin is formed in various reactions. 1. By the action of warm dilute nitric acid on uric acid.—2. By the action of electrolysis, or of reducing agents on alloxan, or by heating it with water or dilute sulphuric acid (see Alloxan): also by dissolving alloxan in dialuric acid.—3. By heating dialuramide (uramil) with dilute sulphuric or hydrochloric acid, or thionurate of ammonium with a large quantity of dilute sulphuric acid.—4. By the action of the air on dialuric acid.—5. In the decomposition of caffeine by chlorine. (Rochleder.)

The following are the most usual processes for the preparation of alloxantin. 1. Dry uric acid is added gradually to warm, very dilute, nitric acid, as long as it is dissolved, and the solution evaporated till it has an onion-red colour; or dilute nitric acid is added to 1 pt. uric acid in 32 pts. water, till all is dissolved, and the solution evaporated to two-thirds; the crystals obtained in either case are purified by re-crystallisation from hot water.—2. Sulphuretted hydrogen is passed through an aqueous solution of alloxan, till a crystalline magma forms; this is dissolved by heat, the precipitated sulphur filtered off hot, and the filtrate crystallised.—3. A solution of alloxan in dilute sulphuric acid is heated for a few minutes, when it becomes turbid, and deposits crystals of alloxantin on cooling.—4. Dialurate of ammonium is evaporated at

ss of dilute sulphuric acid; when dialuric acid crystal-
to alloxantin by the action of the air, without changing
y.)

obtained by the above methods, contains 3 atoms of
it does not lose till heated to above 150°C. Of the
ntin nothing is known. The crystals are small, trans-
, oblique rhombic prisms, hard, but very friable. In
, and 3, the angle of the obtuse lateral edge is 105°:
ained from dialurate of ammonium, it is 121°. They
bit acid properties in other respects. They are very
more abundantly, but still slowly, in boiling water,
ntin separates almost completely on cooling. The fol-
sition of anhydrous and hydrated alloxantin.

Crystals.		*Calc.*	L. and W.	Fritzsche.
C^8	96	29·81	30·52	30·06
H^{10}	40	3·11	3·15	3·04
N^4	56	17·39	17·66	17·52
O^{10}	160	48·67	48·67	49·38
$C^8H^4N^4O^7 + 3aq.$	322	100·00	100·00	100·00

t, alloxantin yields a peculiar crystalline product.
xantin is converted into alloxan. This change takes
solution is exposed to the air, much more rapidly when
r; or when it is diffused in boiling water and a small
Selenious acid also converts the hot solution of allox-
tion of selenium.

sulphuretted hydrogen, a hot solution of alloxantin is

$$+ H^2S + H^2O = \underset{\text{Dialuric acid}}{2C^4H^4N^2O^4} + S.$$

of hydrochloric acid, it is partly decomposed, and de-
der of allituric acid, $C^3H^3N^2O^2$ (Schlieper). At the
banic acid are formed, together with an acid which
hich he has not succeeded in isolating.

ntin gives a violet precipitate, which, on boiling, turns
e solution contains alloxanate and dialurate of barium,

$$)^2 = \underset{\text{Alloxanate Ba.}}{2C^4H^2Ba''N^2O^5} + \underset{\text{Dialurate Ba.}}{C^8H^6Ba''N^4O^8} + 2H^2O.$$

s converted into purpurate of ammonium (murexide).

$$)^7 + 2NH^3 = \underset{\text{Murexide.}}{C^8H^8N^6O^6} + H^2O$$

in the wet or the dry way. In the dry way it occurs
00° C. in an atmosphere of dry ammonia (Gmelin): or
inary temperature to air containing ammonia. In the
of alloxantin is coloured purple-red by ammonia: the
eating, or when left for some time in the cold. When
to the hot alloxantin-solution, so as to form alloxan,
duces a deeper purple colour as the quantity of nitric
oxan, increases; but the coloration ceases when the
into alloxan. When a solution of alloxantin in tho-
with ammonia, and boiled till the purple colour has
amide (uramil) are deposited: the yellow mother-liquor
o the air, deposits crystals of purpurate of ammonium.
lly of mycomelate of ammonium:

$$NH^3 = \underset{\text{Uramil.}}{C^4H^5N^3O^3} + \underset{\text{Mycomel. amm.}}{C^4H^7N^5O^2} + 2H^2O.$$

depends upon the oxidation by the air of some of the
he ammonia. When a solution of alloxantin in aqueous
ted at a gentle heat in an open vessel, the residue being
a, pure oxalurate of ammonium is finally obtained: if the
e does not form.

xantin and sal-ammoniac, both freed from air by boiling, form a purple-red mixture, which soon becomes paler, and deposits colourless or reddish scales of uramil: the mother-liquor contains alloxan and hydrochloric acid:

$$C^8H^4N^4O^7 + NH^4Cl = \underset{\text{Uramil.}}{C^4H^5N^3O^3} + C^4H^2N^2O^4 + HCl.$$

Acetate or oxalate of ammonium acts like the chloride.

8. When aqueous alloxantin is heated with oxide of silver, carbonic anhydride is evolved, silver reduced, and oxalurate of silver formed:

$$C^8H^4N^4O^7 + 4Ag^2O + H^2O = \underset{\text{Oxalurate silver.}}{2C^3H^3AgN^2O^4} + 2CO^2 + 6Ag.$$

From nitrate of silver, alloxantin precipitates metallic silver: the filtrate gives a white precipitate with baryta-water. Aqueous alloxantin dissolves mercuric oxide with evolution of gas, probably forming mercurous alloxanate. By peroxide of lead alloxantin is converted like alloxan. — 9. Aqueous alloxantin is decomposed by long keeping, even out of contact with air, and is converted into alloxanic acid. (Gregory.)

Tetramethyl-Alloxantin, $C^{12}H^{14}N^4O^8 = C^8(CH^3)^4N^4O^7 + H^2O$.—This composition is assigned by Gerhardt to a product of the action of chlorine on caffeine, discovered by Rochleder (Ann. Ch. Pharm. lxxi. 1), also called *Amalic acid* (*q. v.*)—F. T. C.

ALLOYS. (See METALS.)

ALLUAUDITE. (See TRIPHYLINE.)

ALLYL. *Acryl, Propylenyl.* C^3H^5.—Berthelot and De Luca in 1854 (Ann. Ch. Phys. [3] xliii. 257), by acting on glycerin with iodine and phosphorus, obtained the compound C^3H^5I, which they regarded as *iodotritylene*, that is to say, tritylene, C^3H^6, having 1 at. H replaced by iodine, but which is now rather regarded as the iodide of the radicle allyl. Zinin, in 1855 (Ann. Ch. Pharm. xcv. 128) by acting on this iodide with sulphocyanate of potassium, obtained a volatile oil, the sulphocyanate of allyl, $C^3H^5.CyS$, identical with volatile oil of mustard, and afterwards (Ann. Ch. Pharm. xcvi. 361) prepared the benzoate, acetate, &c. of the same series. Hofmann and Cahours, in 1856 (Compt. rend. xlii. 217; more fully, Phil. Trans. 1857, 1; Ann. Ch. Pharm. cii. 285; Chem. Soc. Qu. J. x. 316), discovered allylic alcohol and prepared a great number of its derivatives. Lastly, Berthelot and De Luca in the same year isolated the radical allyl, and prepared the dibromide and diniodide. The existence of this radicle in the oils of mustard and garlic was first demonstrated by Wertheim. (Ann. Ch. Pharm. li. 289; lv. 297.)

Allyl is the third term in the series of homologous radicles C^nH^{2n-1}, vinyl C^2H^3 being the second; it is the only radicle of the series that has yet been isolated.

Allyl, in the free state, $C^6H^{10} = C^3H^5.C^3H^5$, is obtained by decomposing the iodide, C^3H^5I, with sodium at a gentle heat, and afterwards distilling the liquid product. It is a very volatile liquid having a peculiar pungent, ethereal odour, somewhat like that of horse-radish. Specific gravity 0·684 at 14. Boils at 59° C. Vapour-density by experiment 2·92, by calculation from the formula C^6H^{10} (2 vol.) 2·89. Allyl is but little attacked by strong sulphuric acid. Fuming nitric acid changes it into a neutral liquid nitro-compound, soluble in ether and decomposed by heat. Chlorine acts strongly upon it, hydrochloric acid being evolved and a liquid compound formed heavier than water. Bromine and iodine unite directly with it, forming the compounds $C^3H^5Br^2$ and $C^3H^5I^2$. (Berthelot and De Luca.)

ALLYL-ALCOHOL. *Hydrate of Allyl*, $C^3H^6O = \left.\begin{matrix}C^3H^5\\H\end{matrix}\right\}O$.—Prepared by the action of ammonia on oxalate of allyl, oxamide being formed at the same time:

$$\underbrace{(C^2O^2)''(C^3H^5)^2O^2}_{\text{Oxalate of allyl.}} + 2NH^3 = 2\underbrace{(C^3H^5.H.O)}_{\text{Allyl-alcohol.}} + \underbrace{N^2.(C^2O^2)''.H^4}_{\text{Oxamide.}}.$$

Dry gaseous ammonia is passed into oxalate of allyl till the whole is converted into a solid mass of oxamide saturated with allyl-alcohol. The latter is then distilled off in a bath of chloride of calcium, and rectified over anhydrous sulphate of copper. The alcohol appears also to be produced by distilling benzoate or acetate of allyl with potash (Zinin, Ann. Ch. Pharm. xcvi. 362). It is a colourless liquid, having a pungent but not unpleasant odour, and a spirituous burning taste. It mixes in all proportions with water, common alcohol, and ether. It burns with a brighter flame than common alcohol. Boiling-point 103° C.* It gave by analysis, 62·08 per cent. C and 10·43 H, the formula C^3H^6O requiring 62·07 C, 10·34 H, and 27·5 9 O.

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* One sample of the alcohol very carefully prepared, was found to boil between 90° and 100° C. This, however, may have arisen from decomposition; at all events, the number 103° agrees with the differences generally observed in analogous ethyl and allyl-compounds. (Hofmann.)

ed by phosphoric anhydride, a colourless gas, pro-
ich burns with a very bright flame. It is violently
omate of potassium and sulphuric acid, with forma-
C^3H^4O, and acrylic acid, $C^3H^4O^2$. The same trans-
slowly. by platinum black. Potassium (or sodium)
olution of hydrogen and formation of a gelatinous
^4KO. Strong sulphuric acid acts on it in the same
onverting it into allyl-sulphuric acid, $C^3H^5.H.SO^4$.
carbon, it yields the potassium-salt of allyl-xanthic

The *monobromide*, C^3H^5Br, which is isomeric,
tylene, is obtained by the action of bromide of phos-
nn and **Cahours**); or by distilling dibromide of
ate of bromotritylene, $C^3H^5Br.HBr$) with alcoholic
gravity is 1·47, and boiling-point 62° C. (**Cahours**.)
npound, or dibromide of tritylene, is produced when
an excess of tritylene gas; but when tritylene is
umber of compounds are formed which may be re-
omic acid with bromide of allyl having its hydrogen
(See TRITYLENE.)
Br^2.—Allyl unites directly with bromine, the com-
ution of heat. If the action be stopped just as the
excess of bromine, and to give off hydrobromic acid,
d with potash, dibromide of allyl is obtained as a
ether. It melts at 37° C. and when once fused.
nary temperatures. It may be volatilised without
De **Luca**). The allyl in this compound takes the

$^5Br^3$.— Obtained by gradually adding bromine to
ded by a freezing mixture. The mixture is left to
crystallised iodine by washing first with alkaline and
dried and distilled; the liquid which passes over is
ing apart that which goes over from 210° to 220 °C.;
is cooled to 0° C. whereupon it solidifies in a crys-
is drained off; and the product is fused and again
omide of allyl is obtained as a colourless neutral
specific gravity 2·436 at 23° C., boiling at 217°
0°. By slow solidification, it yields shining prisms,
n. Ch. Phys. [3] lx. 84.)
an ethereal substance boiling at 135° C. Heated to
lic ammonia, it is converted into *Dibromallylamine*,
hil. Mag. [4] xvi. 257). The decomposition appears
st, the compound $C^3H^5Br^3$, is converted into $C^3H^4Br^2$,
nverted into dibromallylamine:

$$+ NH^3 = C^3H^4Br^2 + NH^4Br.$$

$$3NH^3 = N\begin{cases}C^3H^4Br\\ C^3H^4Br\\ H\end{cases} + 2NH^4Br.$$

, and heated with acetate of silver to 120°—125° C.
lver and triacetin (p. 25.)

$$\begin{matrix}{}^2H^3O)^3\\ Ag^3\end{matrix} = O^3\begin{cases}(C^3H^5)'''\\ (C^2H^3O)^3\end{cases} + 3AgBr.$$

und is triatomic, replacing 3 at. hydrogen, as seen in
ther words the compound is formed on the type $H^3.H^3$.
ds (or perhaps only one) isomeric with it, by the ac-
e, C^3H^5Br. and on the isomeric body bromide of allyl.
rmed on the type $H^2.H^2$, their rational formula being
specific gravity of 2·392 at 23° C., and boil at about
t in odour and in their action on silver-salts, the
oth respects than the latter (**Wurtz**). The action
monia is totally different from that of tribromide of
allylamine, but to the compound $C^3H^4Br^2.C^3H^5Br^3$

ALLYL, CHLORIDE OF. *Chlorotritylene*, C^3H^5Cl, is obtained like the bromide, by the action of chloride of phosphorus on allyl-alcohol, or by treating chloride of tritylene, $C^3H^6.Cl^2$ (hydrochlorate of allyl-chloride, $C^3H^5Cl.HCl$) with alcoholic potash. The last mentioned compound treated with excess of chlorine yields substitution-products similar to those obtained with the bromide. (See TRITYLENE.)

ALLYL HYDRIDE OF, $C^3H^6 = C^3H^5.H$.— Tritylene or propylene, the third term in the series of hydrocarbons C^nH^{2n}, is perhaps the hydride of allyl.

ALLYL, IODIDES OF. The *monoiodide* (iodotritylene) C^3H^5I, is obtained by distilling glycerin at a gentle heat with diniodide of phosphorus;

$$2C^3H^8O^3 + 2PI^2 = 2C^3H^5I + P^2O^3 + 3H^2O + 2I.$$

A quantity of tritylene-gas is given off, due to a secondary action, and a mixture of oxygen-acids of phosphorus with iodine and undecomposed glycerin remains in the retort. Tri-iodide of phosphorus may also be used, but the action is less regular. The distillate is purified by rectification, the portion which passes over at 100° C. being collected apart (Berthelot and De Luca). Iodide of allyl is also produced by the action of iodine and phosphorus on allyl-alcohol. (Hofmann and Cahours.)

When first prepared, it is colourless, and has an ethereal alliaceous odour; but by the action of air and light, it becomes coloured and then gives off irritating vapours Specific gravity 1·789 at 160° C. Boiling-point 101°. It is insoluble in water, but dissolves in alcohol and ether. By the action of zinc or mercury, and hydrochloric or dilute sulphuric acid, it is converted into tritylene (hydride of allyl):

$$2C^3H^5I + 4Hg + 2HCl = 2C^3H^6 + Hg^2Cl^2 + Hg^2I^2.$$
$$\text{and}\quad 2C^3H^5I + 2Zn + 2HCl = 2C^3H^6 + ZnCl^2 + ZnI^2.$$

Iodide of allyl is decomposed by silver-salts, iodide of silver being formed, and the acid radicle being transferred to the allyl.

Diniodide of Allyl, $C^3H^5I^2$. — Obtained by dissolving 6 or 7 pts. of iodine in 1 pt. of allyl at a gentle heat. The mixture, which is liquid at first, solidifies after a few minutes; and by triturating the mass with aqueous potash, then digesting in boiling ether, and evaporating the ethereal solution, the diniodide of allyl is obtained in the crystalline form. It is decomposed by distillation, yielding iodine and a neutral liquid. It is scarcely attacked by aqueous potash; but alcoholic potash decomposes it, producing a liquid which smells like allyl. It is not acted upon by mercury and hydrochloric acid. (Berthelot and De Luca.)

Iodide of Mercurallyl, $C^3H^5Hg''I$, is obtained by agitating iodide of allyl with metallic mercury. On crystallising the resulting yellow mass from a boiling mixture of alcohol and ether, nacreous scales are formed, which turn yellow when exposed to light, especially if moist. They dissolve but sparingly in cold alcohol, and are nearly insoluble in boiling alcohol. Heated to 100° C. they sublime in rhombic plates; at 135° they melt, and solidify in a crystalline mass on cooling. When quickly heated, they decompose, yielding a yellow sublimate and a carbonaceous residue. The alcoholic solution treated with oxide of silver, yields a strongly alkaline liquid which when evaporated leaves a syrupy mass, probably consisting of hydrate of mercurallyl. (Zinin.)

ALLYL, OXIDE OF. *Allylic ether*, $(C^3H^5)^2O$, is produced by the action of iodide of allyl on allylate of potassium:

$$C^3H^5KO + C^3H^5I = KI + (C^3H^5)^2O;$$

also by the action of oxide of silver or oxide of mercury on iodide of allyl:

$$2C^3H^5I + Ag^2O = 2AgI + (C^3H^5)^2O.$$

A body having the same composition was obtained by Wertheim (Ann. Ch. Pharm. li. 309; lv. 297), by acting on oil of garlic, $(C^3H^5)^2S$, with nitrate of silver, and distilling the crystalline product thereby produced; also by heating oil of mustard (sulphocyanate of allyl), with fixed alkalis, *e. g.* with soda-lime.

Oxide of allyl is a colourless liquid, lighter than water, and insoluble in water. It boils at 82° C. (Hofmann and Cahours); between 85° and 87° C. (Berthelot and De Luca). It forms with sulphuric acid a conjugated acid yielding a soluble barium-salt. Nitric acid converts it into a nitro-compound heavier than water. With iodide of phosphorus, it yields iodide of allyl. Heated with butyric acid it is decomposed, with formation of butyrate of allyl. (B. and L.)

Ethyl-allyl-ether, $C^5H^{10}O = C^2H^5.C^3H^5.O$, is obtained by the action of iodide of ethyl on allylate of potassium, or of iodide of allyl on ethylate of potassium. It is a colourless aromatic, very volatile liquid, boiling at about 84° C. Similar compounds

of allyl with methylate, amylate, and phenylate of
hours). *Amyl-allyl-ether* boils at about 120° C.

yl, or Triallylin, $C^{12}H^{20}O^3 = \left.\begin{matrix}(C^3H^5)'''\\(C^3H^5)^3\end{matrix}\right\} O^3$.—Iodide
glycerin yields this compound in the form of a liquid,
ner, and having a disagreeable odour. (Berthelot

$3C^3H^5I = 3HI + (C^3H^5)'''.(C^3H^5)^3O^3$.

nolecule of water H^6O^3, in which 3 at. H are replaced
yl, and the other three by 3 at. of the monatomic

TS OF. Acetate, oxalate, sulphate, &c. (See the

. *Oil of garlic*, $C^6H^{10}S = (C^3H^5)^2S$ [or C^6H^5S].—This
ing iodide of allyl with protosulphide of potassium:

$+ K^2S = 2KI + (C^3H^5)^2S$,

l oils produced by distilling with water the leaves
the liliaceous and cruciferous orders. It forms the
obtained from the bulbs of garlic (*Allium sativum*),
in the pure state by Wertheim in 1844; and it
of onions (*Allium cepa*). It occurs also, together with
(sulphocyanate of allyl), in the herb and seeds of
when these matters are bruised with water and dis-
fficinalis distilled with water yield oil of garlic; the
theim). The bruised seed distilled after maceration
per cent. oil of garlic, and 90 oil of mustard; but the
ields only the latter. The herb and seeds of *Thlaspi*
r cent. oil of garlic, and 10 oil of mustard. The herb
se yield a mixture of the two oils; and very small
are obtained from the seeds of *Capsella Bursa Pas-*
, and *Sisymbrium Nasturtium*. (Pless, Ann. Ch.

nixed oils, the several parts of the plants, especially
n water some time before distillation. For, in the
mple, the oils do not exist ready formed; the seeds,
ised, and if before distillation with water, they are
h alcohol, no oil passes over; and if the seed be ex-
ltrate evaporated, there remains a crystalline residue
triturated with water and with the seed of *Sinapis*
lic, but oil of mustard. (Pless, Ann. Ch. Pharm.

le of Allyl.—The iodide is cautiously dropped into a
of sulphide of potassium, the liquid then becoming
talline deposit of iodide of potassium being formed.
e liquid is mixed with a slight excess of sulphide of
, and the oil which rises to the surface is rectified.
oil is obtained by distilling bruised garlic-bulbs with
passes over with the first portions of water, the pro-
om 100 pounds of the bulbs. The milky water which
ontains a large quantity of oil in solution, and serves
crude oil is heavier than water, of dark brownish-
ntense odour of garlic. It decomposes at 140° C.;
its boiling-point, which is 150°, becoming suddenly
olour, and giving off intolerably stinking vapours,
lic oil; the residue is a black-brown glutinous mass.

oil.—The crude oil is distilled in a salt-bath (in the
ower) as long as anything passes over. One-third of
s a thick dark-brown residue. The rectified oil is
ale yellow colour, or after two distillations, colourless,
though less offensive. Does not evolve a trace of
hydrate of potash. It covers potassium with a liver-
tassium, depositing an organic substance, and giving
hich burns with a pale blue flame. With fuming nitric

acid, oil of vitriol, hydrochloric acid gas, dilute acids and alkalis, corrosive sublimate, nitrate of silver, bichloride of platinum and nitrate of palladium, it behaves like pure sulphide of allyl. Even after being several times rectified and dried with chloride of calcium, it exhibits a variable composition and a certain amount of oxygen, and must therefore contain, besides sulphide of allyl, an oxygen compound, probably oxide of allyl, the presence of which is indeed indicated by the reaction with potassium. (Wertheim.)

Preparation of pure Oil of Garlic or *Sulphide of Allyl.*—The rectified oil is again rectified several times; dehydrated over chloride of calcium; decanted; a few pieces of potassium introduced into it; and as soon as the evolution of gas thereby produced has ceased, the oil is quickly distilled off from the residue. The rectified oil appears to contain oxide as well as sulphide of allyl, together with excess of sulphur, these impurities either pre-existing in the crude oil, or being formed from sulphide of allyl by the action of atmospheric oxygen, that portion of the sulphide which takes up the oxygen, giving up its sulphur to the rest. If the potassium be not suffered to complete its action before the liquid is distilled, it merely removes the excess of sulphur, but does not decompose the oxide of allyl, and a distillate is obtained, containing from 65·17 to 64·75 per cent. C, and 9·22 to 9·15 H. (Wertheim.)

Properties.— Colourless oil, of great refracting power, and lighter than water. Boils at 140° C. May be distilled without decomposition. Smells like the crude oil but less disagreeably. It dissolves sparingly in water, readily in alcohol and ether

		Calculation.	Wertheim.
6C	72	63·16	63·22
10H	10	8·77	8·86
S	32	28·07	27·23
$(C^3H^5)^2S$	114	100·00	99·31

Decompositions.—1. Sulphide of allyl dissolves with violent action in *fuming nitric acid;* the solution when diluted with water, deposits yellowish-white flakes, and is found to contain oxalic and sulphuric acids; according to Hlasiwetz (J pr. Chem. li. 355) oil of garlic treated with nitric acid, yields formic and oxalic acids.—2. With cold *oil of vitriol*, it forms a purple solution, from which it is separated by water, apparently without alteration.—3. It absorbs *hydrochloric acid gas* in large quantities; the deep indigo-coloured mixture becomes gradually decolorised on exposure to the air, and immediately if gently heated or diluted with water.—4. From *nitrate of silver*, it throws down a large quantity of sulphide of silver, whilst nitrate of silver and allyl remains in solution (Wertheim). It is not altered by dilute acids or alkalis, or by potassium.

Combinations.—Sulphide of allyl does not precipitate the aqueous or alcoholic solutions of acetate of nitrate of lead, or acetate of copper; neither does it precipitate the solution of arsenious or arsenic acid in aqueous sulphide of ammonium.

With solutions of *gold*, *mercury*, *palladium*, *platinum*, and *silver*, it forms precipitates, consisting of a double sulphide of allyl and the metal, either alone or associated with a double chloride.

Gold-precipitate.—Sulphide of allyl forms with aqueous trichloride of gold, a beautiful yellow precipitate, which resembles the platinum-precipitate, but soon cakes together in resinous masses, and becomes covered with films of gold.

Mercury-precipitate. —Alcoholic solutions of oil of garlic and corrosive sublimate form a copious white precipitate, which when left to stand for some time, and especially if diluted with water, increases to a still greater quantity. It is a mixture of the compounds *a* and *b*, which may be separated by continued boiling with strong alcohol, only the compound *a* being soluble therein. (Wertheim.)

a. The alcoholic filtrate, when left to itself or evaporated with water, and after washing and drying, yields a white powder, agreeing in composition with the formula $(C^3H^5)^2S.2Hg''S + 2(C^3H^5Cl.Hg''Cl^2)$, or $2(C^3H^5)^2S.Hg''S.3Hg''Cl^2$ (anal. 10·91 C, 1·61 H, 63·67 Hg, and 16·41 Cl :—calc. 11·32 C, 1·57 H, 62·87 Hg, and 16·70 Cl). It blackens superficially on exposure to the sun; when heated, it gives off vapours smelling like onions, and yields a sublimate of calomel and mercury. When immersed in moderately strong potash-ley, it acquires a light yellow colour from separation of oxide of mercury; if this oxide be then removed by dilute nitric acid, there remains a white substance, probably = $(C^3H^5)^2S.2Hg''S$. When distilled with sulphocyanate of potassium, it yields oil of mustard, together with other products. It is insoluble in water, and dissolves but sparingly in alcohol and ether. (Wertheim.)

b. The portion of the mercury-precipitate insoluble in hot alcohol contains the same constituents, and has the carbon and hydrogen likewise in the ratio of 6 : 5 at., but is much richer in mercury. (Wertheim.)

a rectified oil of garlic is gradually added to a solution
a excess, a brown precipitate is formed, which appears
loride of palladium forms with oil of garlic a yellow
of the preceding compound mixed with chloride of

garlic forms a yellow precipitate with dichloride of
obtained of a finer yellow colour by the use of alcoholic
ol is used, its formation is gradual, becoming instanta-
ater. If the water be added too quickly and in too great
wish-brown, resinous, and difficult to purify; the addi-
stopped as soon as a strong turbidity appears; in that
excess, a copious flocculent precipitate is sure to be ob-
te of ammonium. The precipitate is washed on the filter,
ter, and dried at 100° C.—When heated considerably
nd leaves sulphide of platinum in so porous a condition
perature, and continues to glow till it is reduced to pure
decomposes and dissolves the precipitate completely,
nd platinic sulphate. When immersed in hydrosulphate
onverted into the kermes-brown compound next to be
d sulphuretted hydrogen have no action upon it. The
water, and dissolves but sparingly in alcohol and ether.
cent. C, 2·87 H, 48·53 Pt, 18·29 S, and 13·22 Cl,
e somewhat improbable formula, $3(C^6H^{10}S.PtS^2$ +
17·77 C, 2·47 H, 48·88 Pt, 17·77 S, and 13·11 Cl.
$^3H^5)^2S.PtS^2$.—Formed, together with dissolved sal-
recipitate just described is left in contact and shaken
nium. The brown compound heated to 100° C. emits an
·88 per cent. of sulphide of allyl. The darker substance,
hich remains, continues unaltered till it is heated to
160° gives off 5·17 per cent. more, therefore in all 9·55
aving a still darker compound of $2(C^3H^5)^2S$ with $3PtS^2$.
insoluble in water, alcohol, and ether. (Wertheim.)
solution of nitrate of silver in aqueous ammonia is
of allyl, one portion of the compound resolves itself
o the surface as an oil, and nitrate of ammonium; but
ining a white or pale yellow precipitate, which perhaps
For if it be immediately washed with alcohol, and
ed by distillation into sulphide of allyl and a residue
it remains half an hour immersed in the liquid, it
own colour, and is finally converted into black sulphide

N, SULPHIDE OF. *Allyl-mercaptan*, C^3H^6S =
ling iodide of allyl with sulphide of hydrogen and

+ KHS = KI + $C^3H^5.H.S$.

g an odour like that of oil of garlic, but more ethereal.
lly attacked by nitric acid, assuming a red colour, and
ethyl-sulphurous acid. It acts with great energy on
ound C^3H^5HgS, which dissolves in boiling alcohol, and
early scales resembling mercaptide of mercury. (Hof-

ATE OF. $C^4H^5NS = CNS.C^3H^5$. — *Volatile oil of*
ETHERS.)

AMIC, or **SULPHOSINAPIC ACID.** $C^4H^7NS^2$ =

id is not known in the separate state, but its soluble

metals of the alkalis and alkaline earths, are obtained
the hydrosulphates of those metals: *e. g.*

$^5NS + KHS = C^4H^6KNS^2$.

omposed according to the preceding formula, that is to
ium, $NH^4.H.S$, having 1 at. H in the ammonium-mole-
more by the diatomic radicle CS, or as a compound of
ulphide of hydrogen. The mode of formation leads
ee SULPHOSINAPIC ACID.)

ALLY-SULPHOCARBONIC, or **ALLYL-XANTHIC ACID.** *Sulphide of Allyl, Carbonyl, and Hydrogen*, $C^4H^6S^2O = S^2\left\{\begin{matrix}(CO)''\\H.C^3H^5\end{matrix}\right.$.—When allyl-alcohol is treated with potash and disulphide of carbon, a salt is formed, which crystallises in yellow needles like xanthate of potassium. (Hofmann and Cahours.)

ALLYL-SULPHURIC ACID. $C^3H^5.H.SO^4$.—*Sulphate of Allyl and Hydrogen.* (See SULPHURIC ETHERS.)

ALLYL-UREA. (See CARBAMIDE.)

ALLYLAMINE. $C^3H^7N = N.H^2.(C^3H^5)$, is obtained by the action of ammonia on iodide of allyl, or by boiling cyanate of allyl with strong aqueous potash.

$$CNO.C^3H^5 + 2KHO = CO^3K^2 + N.H^2(C^3H^5).$$

If the alkaline distillate be condensed in hydrochloric acid, a saline mass is obtained, which when distilled with potash, yields, among other products, a basic oil having the composition of allylamine. The platinum-salt, $C^3H^7N.HCl.PtCl^2$, separated from solution by slow evaporation forms magnificent crystals.

DIALLYLAMINE, $C^6H^{11}N = N.H.(C^3H^5)^2$, is formed, together with other products, by the action of iodide of allyl on allylamine.

DIBROMALLYLAMINE, $C^6H^9Br^2N = N.H.(C^3H^4Br)^2$.—Produced by the action of ammonia on tribromide of allyl (p. 141).

$$2C^3H^5Br^3 + 5NH^3 = C^6H^9Br^2N + 4NH^4Br.$$

1 vol. tribromide of allyl is mixed with about 6 vol. of a solution of ammonia in weak alcohol, and heated to 100° C. in sealed tubes for 10 or 12 hours; the liquid is then filtered from the separated bromide of ammonium, and the filtrate mixed with a large quantity of water, whereupon it becomes turbid, and deposits dibromallylamine in the form of a heavy oil, which may be purified by dissolving it in hydrochloric acid, evaporating to dryness at 100° C., redissolving in water, filtering to separate a small quantity of oil, again evaporating, and treating the residue with ether, in which the hydrochlorate is nearly insoluble. From the salt thus purified, the base is separated by distillation with potash. It is alkaline to test-paper, and forms a cloud with hydrochloric acid: it is however but a weak base, incapable of decomposing the salts of copper or silver. It cannot be distilled without alteration. It is but sparingly soluble in water, but dissolves readily in alcohol and in acids. It has a peculiar sweet and aromatic taste. It does not show much tendency to form crystallisable salts. The *sulphate* forms a gummy mass.—The hydrochlorate is a yellowish salt easily soluble in water and alcohol, sparingly in ether. It tastes like the base itself. It assumes a darker colour at 100° C. and sublimes partially at 160°. On adding nitrate of silver to the aqueous solution, the whole of the chlorine is precipitated as chloride of silver, but the bromine remains in solution. The *chloroplatinate*, $2(C^6H^9Br^2N.HCl).PtCl^4$ is an orange-coloured precipitate nearly insoluble in absolute alcohol. Alcoholic solutions of dibromallylamine and chloride of mercury form, when mixed, a copious white precipitate. (Maxwell Simpson, Phil. Mag. [4] xvi. 257.)

Ethyldibromallylamine, $C^8H^{13}Br^2N = N.C^2H^5.(C^3H^4Br)^2$. — Obtained by enclosing dibromallylamine with a large excess of iodide of ethyl in a sealed tube, and heating the mixture to 100° C. for a considerable time. The excess of iodide of ethyl is then distilled off, and the remaining hydriodate of ethylbibromallylamine is dissolved in water and distilled with potash. It has a very bitter and pungent taste, smells like nutmeg, is insoluble in water, soluble in acids, and alkaline to test-paper. It is a stronger base than dibromallylamine, and precipitates oxide of copper from cupric salts. (Simpson.)

TRIALLYLAMINE, $C^9H^{15}N = N.(C^3H^5)^3$, is formed by the destructive distillation of hydrate of tetrallylium.

TETRALLYLIUM, $C^{12}H^{20}N = N(C^3H^5)^4$.—The iodide of this base is the chief product of the action of ammonia on iodide of allyl. The action takes place without the aid of heat, a large quantity of the iodide dissolving after a few days' contact; the solution afterwards deposits splendid crystals of the iodide, and sometimes becomes a solid mass. The separation of the crystals may be accelerated by adding a strong solution of potash, in which the iodide is completely insoluble. The iodide is purified by exposing it to the air till the potash is converted into carbonate, and then recrystallising from absolute alcohol. Treated with oxide of silver, it yields the hydrated oxide of tetrallylium, and the solution of this oxide mixed with hydrochloric acid and bichloride of platinum, forms a yellow salt containing $N(C^3H^5)^4Cl,PtCl^2$.

Tetrallylarsonium, $As(C^3H^5)^4$.—When iodide of allyl is digested with arsenide of

pounds are formed, having a very fetid odour, and at the
body separates, which is the iodide of tetrallyl-arsonium.

diatomic radicle which bears to allyl the same relation
thyl C^2H^5. Respecting its properties in the free state and
ADDENDA (p. 1112).

$H^4.Cl^2$. *Acroleinchlorid.*—Obtained by the action of per-
olein (p. 56). To prevent the action from becoming too
externally cooled, the perchloride of phosphorus covered
nd the acrolein added by small portions at a time. The
o 3 pts. of the perchloride. The crude distillate is shaken
hloride of phosphorus, and further purified by digestion
rectification, the chloride of acrolein passing over at
s oil, having a sweetish ethereal taste, and an odour like
vity 1·170 at 27·5 C. Boiling-point (corrected) 84·4° C.—
y isomeric with chloride of allylene, is likewise formed
phosphorus on acrolein.

ly oxidised by nitric acid. Heated with aqueous nitrate
e of silver. Chlorine converts it into a crystalline com-
e of carbon. Sodium has no action upon it. Heated
appears to yield a compound corresponding to acetal
tube with alcoholic potash, it appears to yield the
chloride of acryl, C^3H^3Cl. Heated in a sealed tube with
niac and acrolein-ammonia (p. 56). (Hübner and
xiv. 36.)

$^{10}O^4 = \left.\begin{matrix}(C^3H^4)'' \\ (C^2H^3O)^2\end{matrix}\right\} O^2$. *Acetate of Acrolein.*—Produced,
a mixture of 1 at. acrolein (C^3H^4O), and 1 at. acetic
heating 1 at. chloride of allylene with 2 at. acetate of
the water-bath for several hours, then to 160° C. in
uct, and collecting apart that which passes over between
$^2H^3O)^2.Ag^2.O^2 = (C^2H^3O)^2.C^3H^4.O^2 + 2AgCl$. It is a
ong fishy odour, and very sharp taste. Specific gravity
t 180°. It slowly reduces an ammoniacal solution of
vith caustic-potash, it yields acrolein and acetate of
ed as a compound of 1 at. acrolein with 1 at. aceti
Iübner and Geuther.)

ive anhydrous sulphate of zinc. (See SULPHATES.)

ARNET.)

Both sweet and bitter almonds yield by pressure a fixed
an agreeable taste, but no odour. Specific gravity 0·918
olein, with but little solid fats, and consequently requires
C.) to solidify it. It easily turns rancid. It dissolves
pts. of boiling alcohol, and mixes in all proportions with

ith cold water and distilled, yield also a volatile oil, of
hydride of benzoyl ($C^7H^5O.H$). This oil does not exist
but is produced by the action of an azotised body,
ntained in the fruit. Sweet almonds do not contain
yield the volatile oil. (See BENZOYL, HYDRIDE OF.)

See ALOETIC ACID.)

uice of various species of aloe, a genus of plants belong-
is chiefly extracted from the *Aloe soccotrina* in Arabia;
formis at the Cape of Good Hope; and from *A. vulgaris*
Jamaica. The best sorts of aloes are prepared by ex-
ich exudes spontaneously from incisions in the leaves;
pressing the leaves. Aloes occurs in commerce in large
ining conchoidal fracture; in thin plates it is red and
ed to a yellow powder. It has an odour like that of
bitter taste. It dissolves completely in alcohol and in
ive purgative properties, due to a crystallisable principle

aloïn, which is contained in it, and may be extracted in a state of purity from Barbadoes aloes.

ALOETIC ACID. $C^7H^4N^2O^6$? *Polychromic Acid. Artificial Bitter of Aloes.*—Produced by the action of nitric acid upon aloes, chrysammic acid being formed at the same time (Schunck, Ann. Ch. Pharm. xxxix. 24; lxv. 235; G. J. Mulder, J. pr. Chem. xlviii. 39). 1 part of aloes is gently heated with 8 pts. of moderately strong nitric acid till gas begins to escape; the vessel is then removed from the fire, and as soon as the disengagement of gas ceases, the solution is concentrated by evaporation, till a yellow powder separates, the quantity of which may be increased by addition of water. The aloetic acid is separated from the chrysammic acid in this powder by treatment with boiling alcohol, which dissolves the aloetic acid; and on evaporating the solution, the acid is obtained in the form of an orange-yellow powder having a bitter taste. It is but slightly soluble in water, but dissolves more freely in boiling water, forming a solution of a splendid purple colour, which is changed to yellow by nitric acid, but restored by alkalies. It is dissolved by ammonia, potash, and soda, forming purple solutions. Strong nitric acid converts it into chrysammic acid. It is monobasic. The *barium*-salt, $C^{14}H^6Ba''N^4O^{12}$, is a brown-red nearly insoluble powder, obtained by precipitating the aqueous acid with acetate of barium. The *potassium*-salt separates by slow evaporation in crystals of a fine ruby colour. According to Schunck, the formula of aloetic acid is $C^{16}H^4NO^{12}$; according to Mulder $C^{14}H^3N^2O^{11}$. According to the formula above given, it is isomeric with dinitrobenzoic acid.

The alcoholic mother-liquor obtained in the preparation above described contains another acid called *Aloeretic acid*, $C^7H^3ON^6$? which, according to Mulder, is the first product of the action of nitric acid on aloes. It is separated by neutralising with chalk, mixing the filtrate with acetate of lead, decomposing the lead-precipitate with hydrosulphuric acid, and evaporating. It is a brown amorphous mass, which when boiled with nitric acid is converted first into aloetic, then into chrysammic acid. (Mulder.)

The name aloeretic acid is also applied by Schunck to an acid produced by the action of alkalis on chrysammic acid, and called by Mulder *chrysatric acid* (which see).

ALOÏN. $C^{17}H^{18}O^7$.—A crystalline bitter principle obtained from aloes: also called *Bitter of aloes*; discovered by T. and H. Smith (Chem. Gaz. 1851, p. 107). It is prepared by mixing Barbadoes aloes with sand, to prevent agglomeration, treating it several times with cold water, and evaporating the aqueous extract in vacuo to the consistence of a syrup. It then separates in small crystals. The solution must not be heated to the boiling-point, since aloïn undergoes alteration at 100° C.

According to Dr. Stenhouse (Phil. Mag. [3] xxxvii. 481), the Cape and Socotrin aloes contain large quantities of foreign matters which prevent the crystallisation of the aloïn; he has succeeded in isolating the aloïn, only by operating on the Barbadoes aloes.

Pure aloïn separates from an alcoholic solution, in the form of small prismatic needles, grouped in stars, of a pale yellow colour. Its taste is at first sweet, then extremely bitter. It is much more purgative than aloes itself. In the cold, it is but slightly soluble in water and alcohol, but dissolves better when hot; the solutions are yellow and neutral to test-paper. Dried at 100°C. it contains $C^{17}H^{18}O^7$.

The caustic and carbonated *alkalis* dissolve aloïn with a bright yellow colour.

By digestion with concentrated *nitric acid*, aloïn is transformed into chrysammic acid. *Chlorine* passed into an aqueous solution of aloïn, produces a bright yellow precipitate, *chloraloïl*, containing, according to Robiquet, $C^{12}ClO^6$. Solution of *chloride of lime* colours aloïn bright yellow, this tint passing rapidly to brown.

Bromine added in excess to a cold aqueous solution of aloïn produces a yellow precipitate of *bromaloïn*, $C^{17}H^{15}Br^3O^7$? which dissolves in boiling alcohol, and separates in shining yellow needles, grouped in stars, and much larger than the crystals of aloïn. It is less soluble in cold water and alcohol than aloïn: the solutions are neutral.

ALOISOL.—$C^6H^8O^2$? An oily liquid obtained in very small quantity by distilling aloes with half its weight of quick lime. It is colourless, has a sharp penetrating odour, is insoluble in water, but mixes in all proportions with alcohol and ether. Specific gravity 0·877. Boiling-point 130°C. By contact with the air, or by the action of strong nitric acid on chlorine water, it is converted into a brown-red liquid, heavier than water, and having a very decided odour of castoreum. Treated with oxide of copper or chromic acid, it yields carbonic acid, water, and hydride of benzoyl. (Robiquet, J. Pharm. [3] x. 167 and 241.)

ALOUCHI, or **ALUCHI RESIN** is imported from Madagascar, where it is

t de Bomare, from a tree called Timpi. According to
a. It is friable. whitish on the outside, black within,
l a strongly aromatic, peppery, bitter taste. According to
it contains 68·12 p. c. of resin easily soluble in cold
gly soluble in cold alcohol, 1·58 essential oil, together
acid and ammonia-salt, besides earthy impurities. The
to be of peculiar nature.

E OF. (See Sulphocyanide of Ammonium.)

eral having the same composition as *barytocalcite*,
ng in macled double six-sided pyramids, of the trimetric
forms monoclinic prisms: hence carbonate of barium
Alstonite is found on Alston Moor in Cumberland.

IDE OF LEAD.)

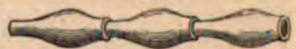
ARAGIN.

$C^2H^6SO^4$.—This acid, isomeric with ethylsulphuric or
according to Regnault (Ann. Ch. Phys. [2] lxv. 98),
cess of strong sulphuric acid till olefiant gas begins to
80° C.) When equal parts of sulphuric acid and alcohol
nic acid is formed, and even in the residues of the ether-
the latter is the only acid found.
f althionic acid, the residue obtained in the preparation
phuric acid and 1 pt. alcohol, is saturated with milk of
tion, is treated with oxalic acid to precipitate the lime;
turated with baryta-water; the excess of baryta preci-
he filtrate evaporated, first by heat, and finally in vacuo,
ce as soon as the liquid acquires a syrupy consistence.
stallisation, forms spherules composed of small needles
ng off 8·59 p. c. (1 at.) of water in vacuo. The formula
$^5BaSO^4 + H^2O$. It is more soluble in water than the
ssolves also in alcohol especially when hot.
f the barium-salt, the free acid (the hydrogen-salt) may
he baryta with sulphuric acid, and from this the other
ect combination. The *calcium*-salt evaporated at the
ies completely in a mass, without crystallising. The
ery thin rhombohedrons, having an acute angle of 60°.

523) was not able to find althionic acid in the residues
gas, but only ethionic, isethionic, and sometimes also

earthern vessels used by the older chemists for sub-
ach end and fit into
hown in *fig.* 7. At
den in Spain, vessels
dense the mercurial
rts. For this pur-
n of a chain on a slightly inclined surface called the

Fig. 7.



)

unds of alumina with the stronger bases.

sulphate of aluminium, $Al^4O^3.SO^3 + 9HO$, found native
t is a white, opaque, earthy mass, of specific gravity
acid. Gives off its acid at a red heat. (Stromeyer.)

Al; *Atomic weight*, 27·4.—This metal occurs in a
oxide (alumina) anhydrous, and hydrated, sometimes
ociated with the oxides of other metals, iron zinc,
s sulphate and phosphate; as silicate, which is the chief
combination with other silicates, forms a vast number
pars; also as mellitite, or honeystone, as fluoride of
lite; and in very small quantities in plants.
to be a distinct earth by Marggraff in 1754, having
ith lime. Oerstedt, in 1826, showed how to prepare

the chloride of aluminium by passing chlorine over a red-hot mixture of alumina and charcoal; and **Wöhler**, in 1828 (Pogg. Ann. xi. 136) succeeded in eliminating the metal by igniting the chloride with potassium. It was thus obtained in the form of a grey powder intermixed with tin-white globules arising from partial fusion. It has lately been obtained in the compact form, and in much larger quantity, by H. Sainte-Claire Deville and others.

Preparation.—The mode of preparation now adopted is the same in principle as that of Wöhler, depending on the action of sodium at a red heat on the chloride or fluoride of aluminium, or better, on the double chloride or double fluoride of aluminium and sodium. Sodium is used to effect the reduction in preference to potassium, partly because it acts more regularly and with less violence, and partly because it is more easily prepared, and, having a lower atomic weight than potassium, a smaller quantity of it suffices for a given amount of chemical work.

The process first adopted by Deville consisted in passing the vapour of chloride of aluminium over sodium contained in a tube of iron or copper which was kept at a dull red heat. Metallic aluminium was thus obtained, mixed with chloride of aluminium and sodium. The latter was removed by washing with water, and the metallic globules which remained were made to unite by heating them till they began to melt, and pressing them together with a pipe-stem. The mass thus obtained was then remelted and cast into bars. Another method which promised to yield good results, but has not yet been perfected, was to reduce the chloride of aluminium by vapour of sodium. The mixture of carbonic oxide and sodium-vapour produced by heating a mixture of charcoal and carbonate of sodium (see SODIUM) was conveyed into a large earthen crucible by means of an iron tube passing through a hole near the bottom and reaching nearly to the other side; and as the sodium and carbonic oxide burned and thereby heated the crucible, portions of chloride of aluminium were thrown in from time to time. The crucible when cold was broken, and the aluminium separated from the saline mass in the manner above described.

The quantity of compact aluminium obtained by these methods was however considerably below the theoretical amount, a large portion of the metal being reduced in the form of a fine powder which re-fused to unite into globules. This inconvenience may be obviated and much better results obtained by the use of fluor spar or cryolite as a flux. These fluorides assist the union of the particles, apparently by dissolving small quantities of alumina—produced by moisture adhering to the chloride,—which surround the particles of metal at the moment of reduction, and, not being decomposed by the sodium, prevent them from uniting into globules. The reduction may be performed in crucibles, or better, in a reverberatory furnace.

a. 400 parts of chloride of aluminium and sodium, 200 pts. of chloride of sodium, 200 pts. of fluor spar or cryolite—the latter being preferable—all perfectly dry and finely pulverised, are placed together, with 75 or 80 pts. of sodium, in alternate layers, in an earthen or iron crucible, which is moderately heated till the action begins, and afterwards to redness, the melted mass being stirred with an iron rod and afterwards poured out. If the process goes on well, 20 pts. of aluminium are thus obtained in a compact mass, and about 5 pts. more in globules encrusted in a hard mass.

The aluminium thus obtained is, however, somewhat contaminated with silicon, derived from the earthy matter of the crucible, which is attacked by the sodium, by the aluminium itself, and by the fluorides in the slag. This evil may be corrected to a certain extent, but not completely, by lining the crucible with a paste composed of calcined alumina, or aluminate of calcium. If iron crucibles are used, the aluminum is found to contain iron.

b. The reduction is performed with greater facility, and on a much larger scale, by heating the mixture on the hearth of a reverberatory furnace.

The proportions used are:

Chloride of aluminium and sodium	10 parts.
Fluor spar or cryolite	5 "
Sodium	2 "

The double chloride and the cryolite or fluor spar are mixed in the state of powder with sodium in small ingots, and the whole is thrown on the hearth of the furnace previously raised to the required temperature. The dampers are then closed to prevent access of air. A vivid action soon takes place, accompanied by evolution of heat, sufficient to raise the walls of the furnace and the mixture itself to bright redness; and the mixture is almost completely liquefied. When the reduction is complete, the fused mass is run out through an aperture at the back, the slag escaping first, and then the aluminium flowing out in a single jet, and collecting in one mass below the liquid slag. With a furnace having a hearth about 16 square feet in surface, about

btained at one operation. The slag consists of two
rge quantity of common salt, while the lower, which is
chiefly of fluoride of aluminium. On pulverising this
ieve, an additional quantity of aluminium is obtained
minium may be used for the preparation of alumina.

patented by MM. Rousseau, Frères and M. Paul Morin,
untry, 1856, No. 1810) is peculiarly advantageous in
etal is very little exposed to contamination with silicon.
generally arises from the action of the sodium or of the
e vessels in which the reduction takes place. Now,
e heat is applied from below, the part of the mixture
s necessarily the hottest, and consequently the action
lerable; but when the mixture is fused on the hearth
the flame playing on its surface, the coolest part is in
s therefore less acted upon. Moreover with the pro-
of the fluorine is separated as fluoride of aluminium,
ttle action on silicious substances.

The pulverised mineral is mixed with half its weight
e is arranged in alternate layers with sodium (2 pts.
in an earthen or iron crucible, a layer of pure cryolite
hole covered with common salt. The mass is rapidly
, and then left to cool after being stirred with an iron
lly found in large globules. Such was the method
r H. Rose in Berlin, and by Dr. Percy and Mr. Allen
carried on, on the manufacturing scale, at Amfreville,
er.

ecting the reduction of aluminium, either from the
, the object of which is to prevent loss of sodium by
d patented by F. W. Gerhard (1858, No. 2247). It
ace having two hearths, or two crucibles or reverbe-
ve the other, and communicating by an iron pipe. In
of sodium with the aluminium-compound, and in the
odium, or of a mixture of sodium and cryolite, or of
eration. This layer when melted, is made to run into
sufficient to cover completely the mixture contained
the air.

sing cryolite as a source of aluminium, is that it is
tolerable facility, and enables the manufacturer to
and costly preparation of the chloride of aluminium
um thus obtained is less pure than that prepared from
thod previously described. If earthen crucibles are
ated with silicon, because the fluoride of sodium pro-
strongly on the silicious matter of the crucible; and
he aluminium takes up a portion of that metal. For
nion, that the best use of cryolite is as a flux in the
the double chloride. In that case, as already observed,
of sodium, but of fluoride of aluminium, which acts
essel.

eans of hydrogen or carbon. — Several attempts have
ccess, to separate aluminium from its compounds by
agents.

luoride of aluminium, or the double fluoride of alumi-
, by subjecting it to the action of hydrogen gas at a
ound is placed in a number of shallow dishes of glazed
rrounded by a number of other dishes containing iron
ed in an oven previously heated to redness; hydrogen
heat increased. Aluminium is then separated, and
h is immediately taken up by the iron filings, and
on the aluminium. To prevent the pressure of gas
t-tube is provided, which can be opened or closed at
. This process, which was patented in 1856 (No. 2980),
d good results; the inventor has however since returned
ducing agent, sodium (see above), which would seem
hod has not quite fulfilled his expectations.

patented a process (1857, No. 1742) for reducing alu-
ans of cyanide of potassium or cyanide of sodium, the

chloride, either in the fused state or in the form of vapour being brought in contact either with the melted cyanide or its vapour. Pure alumina may be added to increase the product.

L. F. Corbelli, of Florence, states that aluminium may be obtained by mixing the impure sulphate (prepared by heating clay with strong sulphuric acid), with 2 pts. of ferrocyanide of potassium, and 1½ pt. common salt, and heating the mixture to whiteness. The metal thus obtained must however be very impure, perhaps consisting chiefly of iron. The process was patented in this country in 1858 (No. 142).

M. Cumenge, of Paris, obtains aluminium from the sulphide (Al^4S^3) either by heating that compound in an atmosphere of hydrogen, or by heating it with alumina or sulphate of aluminium, in such proportion that the oxygen contained in that compound shall be just sufficient to convert the whole of the sulphur into sulphurous anhydride:

$$Al^2S^3 + 2Al^2O^3 = 3SO^2 + 6Al$$

$$\text{or} \quad Al^2S^3 + Al^2(SO^4)^3 = 6SO^2 + 4Al;$$

or, lastly, by decomposing the sulphide with an ordinary metal, such as iron, copper or zinc. This process is also patented (1858, No. 461).

Preparation of Aluminium by Electrolysis. — The electrolytic reduction of aluminium may be performed either in the dry or in the wet way. The reduction from fused chloride of aluminium and sodium was first effected in this manner by Bunsen in 1854 (Pogg. Ann. xcii. 648). The salt is introduced in a fused state into a red-hot porcelain crucible, divided into two parts by a porous earthenware diaphragm, and the extremities of the carbon poles of a Bunsen's battery of ten elements are introduced into the two halves of the fused mass. The metal is then reduced at the negative pole. The heat must be raised considerably above the melting-point of the double chloride, otherwise the aluminium separates in the pulverulent form. It is best to add fresh quantities of chloride of sodium during the reaction, and to raise the temperature ultimately to the melting point of silver. The aluminium is then obtained in globules of considerable size, which may be melted into one by throwing them into chloride of sodium melted at a white heat. Deville adopts a similar method, using, however, platinum instead of charcoal for the negative pole.

The same method may be used for coating metals with aluminium. Thus, if a bar of copper be used as the negative pole, and a bar of aluminium as the positive pole, tha latter dissolves as the action goes on, and is deposited upon the copper.

Aluminium may also be reduced by the action of the current from the solution of its salts. Mr. Gore has in this way obtained a deposit of aluminium on copper, and Messrs. Evans and Tilley have patented a process (1855, No. 2756), for coating metals with aluminium and its alloys, by electrolysing a solution of alumina mixed with cyanide of potassium, the negative pole being formed of the metal to be coated, and the positive pole of platinum or aluminium, or of some other metal, such as copper, tin or silver, which is to be deposited together with the aluminium. The bath may also in some instances be composed of a mixed solution of aluminium and the other metal to be deposited.—M. Corbelli, of Florence, obtains a deposit of aluminium by electrolysing a mixture of rock-alum or sulphate of aluminium with chloride of calcium or chloride of sodium, the positive pole being formed of iron wire coated with an insulating material and dipping into mercury placed at the bottom of the solution, and the negative pole of zinc immersed in the solution. Aluminium is then deposited on the zinc, and the chlorine eliminated at the positive pole unites with the mercury, forming calomel. This process is also patented (1858, No. 507).

Of all the processes above described, the only one that has been successfully applied to the production of aluminium on the large scale, is the decomposition of the double chloride or of cryolite by sodium. The electrolytic method is too expensive, excepting for producing a thin coating of aluminium on other metals; and the attempts which have been made to obtain aluminium by means of the ordinary reducing agents, such as hydrogen and charcoal, do not appear to have led to very satisfactory results. At present, therefore, the progress of the aluminium manufacture depends essentially on the economical production of sodium; and indeed the manufacture of aluminium has already given a great stimulus to that of sodium, and has led to considerable improvements in that process, and consequent reduction of cost. (See SODIUM.) *

Purification.—Aluminium may be purified from *copper* and *iron* by fusion with nitre in an iron crucible, the foreign metals being thereby oxidised, while the aluminium remains

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* When Deville commenced his experiments in 1854, great hopes were entertained that aluminium might be produced at a price sufficiently low to admit of a variety of useful applications. Hitherto these expectations have been but imperfectly fulfilled, the metal being still too costly to be applied to other than ornamental purposes. Still, however, great progress has been made, the price, which in 1856 was 3*l.* per oz., being now reduced to 5*s.*; and further reduction will doubtless be made as the details of the manufacture are improved.

aluminium, the inner surface of the crucible should be
the nitre. Aluminium containing zinc, may be freed
e alloy in contact with the air. No method has yet
minium from *silicon*.
tain portions of the slag in the midst of which it has
e, when worked and polished, to exhibit a number of
gradually became more and more conspicuous. The
elt the metal in an open black lead crucible for a con-
om the fire and stir it with an iron skimmer oxidised
the whitish slaggy matter is removed, together with a
which may be set aside to be remelted. The metal is
le operation repeated three or four times.
ting the preparation of aluminium, see *De l'Aluminium*,
ro. Paris, 1859; *L'Aluminium et les Métaux Alcalins*,
et Rouen, 1858; *Chemical Technology*, by Richard-
p. 1; *Ure's Dictionary of Arts, Manufactures and*

hite metal, with a faint tinge of blue. It takes a fine
osted, like that of silver, by plunging it for an instant
tic soda, washing with a large quantity of water, and
acid. When pure, it is quite destitute of taste and
ductile; may be beaten and rolled as easily as gold
xtremely thin wire. In this last operation, however,
ires to be tempered by cautiously heating it over a
, it is about equal to silver. After fusion it is as soft
ring in the cold, it acquires the hardness of soft iron
the metal suspended by a thread and struck with a
clear, ringing sound. It is very light, being not much
s water, and about 4 times lighter than silver. Its
fter being hammered in the cold, 2·67. Its melting-
e melting-points of zinc and silver, but nearer to the
greatest ease in metallic moulds, and still better in
ed without any flux; indeed, the addition of a flux
erwise, the metal attacking borax and glass with
a closed vessel, does not exhibit the slightest tendency

of aluminium is eight times as great as that of iron,
; it conducts heat even better than silver. Its specific
ough its melting-point is comparatively low, it takes
elting together of small pieces of the metal may be
le and pressing them together with an iron rod oxi-
slowly cooled from fusion, it exhibits a crystalline
, however, most distinct when the metal is impure.
ts solutions by electrolysis at low temperatures, crys-
pear to be regular. It is slightly magnetic.
in the *air*, even at a strong red heat; neither does it,
ecompose water, excepting at a white heat, and even
is not attacked by *sulphuretted hydrogen*, or even by
nsequently preserves its lustre in the atmosphere of
soon tarnished and blackened. It may also be heated
without showing any disposition to combine; at very
bination takes place.
nitric acid, either dilute or concentrated, at ordinary
ven at the boiling heat; neither is it acted upon by
egree at which that acid dissolves zinc; but *hydro-*
entrated, dissolves it readily, even at low temperatures,
The *vegetable acids*, such as acetic and tartaric acid,
luminium; a mixture of acetic acid and common salt
n, because it contains free hydrochloric acid; but even
w, and not nearly so great as would be exerted upon
s. Aluminium would therefore be well adapted for
small quantity of alumina which might be formed from
mixtures would not exert any deleterious action on the

d *sodium* in the state of fusion do not act upon alu-
ions dissolve it readily, forming aluminate of potassium
gen. Ammonia acts but slightly on it.

A solution of *common salt* or *chloride of potassium* is also without action on aluminium, but the solutions of many other chlorides dissolve it, and more readily, as the metals which they contain are higher in the scale; even a solution of chloride of aluminium dissolves the metal, forming a basic chloride. Solutions of *sulphates* and *nitrates*, on the contrary, do not act upon it. Hence in precipitating other metals upon aluminium by electrolytic action, it is necessary to use acid solutions not containing hydrochloric acid or any chloride. In an acid solution of sulphate of copper, the aluminium quickly becomes coated with metallic copper.

Aluminium may be fused with *nitre* at a moderate heat, without undergoing the slightest alteration; hence this process may be adopted for purifying aluminium from admixtures of other metals. If however the heat be raised till the nitric acid is completely decomposed and begins to give off nitrogen, a new reaction takes place attended with incandescence, and aluminate of potassium is formed.

Uses.—The lustre and whiteness of this metal, its unalterability in the air, and the facility with which it takes a frosted surface, render it well adapted for jewellery, for which purpose it is now much used. It also makes very bright reflectors. Its lightness renders it useful for mounting astronomical instruments, especially sextants. It may also be used for making small weights, such as the divisions of the gramme. Very delicate balance-beams have also been constructed with it. For culinary vessels it is adapted by its lightness and the little tendency which it has to become corroded by any of the liquids likely to come in contact with it. It is necessary however to observe, that this power of resisting the action of corroding agencies, and more especially those of the atmosphere of large towns, is exhibited only by the pure metal. Now, much of the aluminium of commerce is very impure, being contaminated with iron or silicon, or not having been properly freed from slag. Aluminium thus contaminated soon becomes tarnished, and much disappointment has been experienced from this cause by many who have used it for ornamental purposes. According to Deville, the impurities just mentioned are found to the greatest amount in the metal obtained from cryolite (p. 152).

General Characters and Reactions of Aluminium-compounds.—Aluminium forms only one class of salts, and into these it may be supposed to enter as a tri-equivalent radicle, 1 atom of aluminium taking the place of 3 atoms of hydrogen: $Al = H^3$, or $Al^2 = H^6$. Thus, the chloride of aluminium is $(Al^2)^{vi}Cl^6$; the oxide (alumina) is Al^2O^3; the sulphate, $(Al^2)^{vi}.3SO^4$, or $\left.\begin{matrix}(3SO^2)^{vi}\\(Al^2)^{vi}\end{matrix}\right\}O^6$, &c. These formulæ are based upon the isomorphism of the aluminium-compounds with other compounds of corresponding character, which are known or supposed to contain tri-equivalent radicles: thus, alumina, the only known oxide of aluminium, is isomorphous with sesquioxide of iron and sesquioxide of chromium; and common potash-alum, $Al'''K'(SO^4)^2 + 12H^2O$, is isomorphous with iron-alum, $Fe'''K'.(SO^4)^2 + 12H^2O$, and chrome-alum, $Cr'''K'.(SO^4)^2 + 12H^2O$. All these formulæ may, however, be reduced to others containing bivalent radicles, the values of which are two-thirds of those of the corresponding tri-equivalent radicles. For instance, the aluminium-compounds may be supposed to contain a radicle (*aluminicum*), $al'' = \frac{2}{3}Al''' = \frac{2}{3} . 27{\cdot}4 = 18{\cdot}3$. The formula of the chloride will then be $al''Cl^2$; that of alumina, $al''O$; that of the sulphate, $al''SO^4$; that of alum, $al''K^2(SO^4)^2$. It is sometimes convenient to write the formulæ in this manner.

Most compounds of aluminium are colourless. The oxide, hydrates, borates, phosphates, arseniates, and silicates, are insoluble in water; most other aluminium-compounds are soluble. All of these, excepting the silicates, are soluble in hydrochloric and sulphuric acid, at least if they have not been strongly ignited.

The aqueous solutions have an acid reaction, and an astringent disagreeable taste. They are not precipitated by any free acid. With *sulphide of ammonium* and other soluble sulphides, they give a white gelatinous precipitate of trihydrate of aluminium, the formation of which is attended with evolution of hydrosulphuric acid gas. The precipitate is insoluble in excess of that reagent, but soluble in caustic potash or soda. With solution of *potash* or *soda*, the same gelatinous precipitate of the hydrate is produced, soluble in excess of the alkali, and reprecipitated by boiling with sal-ammoniac, or by cautious neutralisation with hydrochloric acid.—With *ammonia*, the same precipitate, insoluble in excess.—With *alkaline carbonates*, the same, carbonic acid being given off, and not entering into combination with the alumina.—With *ferrocyanide of potassium*, a white gelatinous precipitate, after some time.—With *phosphate of sodium*, gelatinous precipitate, closely resembling the hydrate in appearance, and dissolving with the same facility in hydrochloric acid and in potash. From these solutions it is precipitated in the same manner as the hydrate, viz. from the hydrochloric acid solution by ammonia, and from the potash-solution by sal-ammoniac; it is distinguished

its insolubility in acetic acid, and by exhibiting certain
v.)
n, when moistened with a small quantity of *nitrate of*
owpipe, exhibit a fine characteristic blue colour. This
placing a small quantity of alumina, precipitated as
foil, heating it to redness, then moistening with nitrate

luminium.—Aluminium is usually precipitated in the
nmonia or carbonate of ammonium, or better by sul-
n excess of ammonia or its carbonate dissolves a
of the hydrate, which can then be reprecipitated only
trace of ammonia is expelled. The precipitate when
a, containing 53·26 per cent. of the metal.
conveniently separated from its solutions by boiling
alumina is then precipitated together with sulphur,
d, and a sodium-salt of the acid previously combined
lution: thus, if the aluminium exists in solution as

$$a^2 = Al^2O^3 + 3S + 3SO^2 + 3SO^4Na^2.$$

must be boiled till it no longer smells of sulphurous
quickly in a compact mass, not at all gelatinous, and
r mixed with it is very easily expelled by ignition
. 987.)
by hyposulphite of sodium, serves also to separate
ecially from iron, the latter metal being reduced to the
g in solution as a sodio-ferrous hyposulphite. To
solution must be nearly saturated, if necessary, with
o a considerable extent, and mixed with the hypo-
he alumina separates too quickly, before the iron is
e, and then carries some of the iron down with it
nina, the iron is re-oxidised by nitric acid and preci
l.)
ated from the *alkalis* and *alkaline earths*, by precipi-
ide of ammonium. In thus separating it from the
must be taken to protect the solution from the air,
absorbed by the excess of ammonia, and will preci-
her with the alumina. From *barium*, aluminium is
ic acid.

luminium forms alloys with most metals. With *zinc*
g brittle alloys; with *cadmium* it forms a malleable
unites in all proportions, forming alloys which are
long needles, when the proportion of iron amounts
containing iron dissolves in acids more readily than

a small proportion of *silver*, loses all its malleability.
. of silver may, however, be worked like the pure
aking knife-blades. An alloy containing 3 per cent.
mental articles. It has the colour and lustre of silver,
tted hydrogen. (Deville.)
copper are of especial importance. One in particular,
with 90 pts. of copper, called *aluminium-bronze*,
erties. It is a definite compound, containing Cu^9Al.
a high polish, is extremely hard, and possesses a
t steel; it is also very malleable. Another alloy con-
opper, is used for casting ornamental articles of large
d. Aluminium may be easily plated on copper. The
ared in the usual manner, and well rubbed with sand,
of iron, the whole being well bound together, heated
pressed. (Deville.)
prepared by heating a mixture of alumina and the
copper, iron, or zinc, or a mixture of alumina with
the free state, granulated copper, for instance, the
divided, and mixed in atomic proportions; or rather
s. This method, due to a foreign inventor, has been
ame of E. L. Benzon (1858, No. 2753).

Amalgamation and Gilding of Aluminium.—According to Cailletet, aluminium may be amalgamated by the action of ammonium-amalgam or sodium-amalgam and water, also when it is connected with the negative pole of the voltaic battery, and dipped into the mercury moistened with acidulated water, or into nitrate of mercury.—Ch. Tissier (Compt. rend. xlix. 56), confirms this statement respecting the amalgamation of aluminium in connection with the negative pole of the battery, and adds, that if the aluminium foil is not very thick, it becomes amalgamated throughout, and very brittle. The same chemist finds that aluminium may be made to unite with mercury, merely by the use of a solution of caustic potash or soda, without the intervention of the battery. If the surface of the metal be well cleansed and moistened with the alkaline solution, it is immediately melted by the mercury and forms a shining amalgam on the surface.

The amalgam of aluminium instantly loses its lustre when exposed to the air, becoming heated and rapidly converted into aluminium and metallic mercury. It decomposes water, with evolution of hydrogen, formation of alumina, and deposition of mercury. Nitric acid attacks it with violence. (Tissier.)

To *gild* aluminium, 8 grammes of gold are dissolved in aqua regia, the solution is diluted with water and left to digest till the following day, with a slight excess of lime; after being well washed, it is treated at a gentle heat with a solution of 20 grms. of hyposulphate of sodium. The filtered liquid serves for the gilding of aluminium, without the aid of heat or electricity, the aluminium being simply immersed in it, after having been well cleaned by the successive use of potash, nitric acid, and pure water. (Tissier.)

It is somewhat difficult to *solder* aluminium, partly because no flux has yet been found that will clean the surface without attacking either the aluminium or the solder, partly because the surface of the aluminium is not easily melted by metals more fusible than itself. An imperfect soldering may indeed be effected by means of zinc or tin, but a better method, devised by M. Hulot, is to coat the aluminium with copper, by the electrolytic method, and then solder in the ordinary way. (Deville.)

Arsenide of Aluminium. (See ARSENIDES.)

Boride of Aluminium. Boron unites with aluminium under the same circumstances as silicon (p. 160), and alters its properties in a similar manner.

Bromide of Aluminium, Al^2Br^6, is obtained by the action of bromine on pulverulent aluminium, the metal being in excess. By sublimation, it is obtained in white, shining laminæ, which melt at 90°, forming a mobile liquid which boils at about 265° C. It is decomposed when heated in contact with the air. It dissolves in bisulphide of carbon, forming a solution which fumes strongly in the air. It dissolves in water, and the solution evaporated in vacuo over oil of vitriol, leaves needle-shaped crystals containing $Al^2Br^6 + 12H^2O$. With bromide of potassium, it forms the double salt $2KBr.Al^2Br^6$. It absorbs ammonia and hydrosulphuric acid, forming compounds which are decomposed by heat. (R. Weber, Pogg. Ann. ciii. 254.)

Chloride of Aluminium, Al^2Cl^6.—The finely divided metal heated to redness in a current of dry chlorine gas, takes fire and is converted into the chloride, which sublimes (Wöhler). The compound is also produced by passing dry chlorine over an ignited mixture of alumina and charcoal: and this is the method adopted for preparing it. Hydrate of aluminium precipitated from a hot solution of alum by an alkaline carbonate is made up into small pellets with oil and lampblack, and the mixture is strongly ignited in a crucible: the oil is then decomposed and an intimate mixture of alumina and charcoal remains. This is introduced into a porcelain tube or tubulated earthen retort placed in a furnace, and connected at one end with an apparatus for evolving chlorine, and at the other with a dry receiver. On raising the heat to bright redness, and passing chlorine through the apparatus, chloride of aluminium is formed and condenses in a solid mass in the receiver.

A similar process is adopted in preparing the compound on the large scale. Alumina or clay is mixed with coal, pitch, tar, resin, or any organic substance that will decompose by heat and leave a considerable quantity of charcoal, and the mixture, after being well calcined, is heated to redness in a cylinder of earthenware or cast iron, through which a current of dry chlorine is made to pass. The vapours of chloride of aluminium pass into a condensing chamber lined with plates of glazed earthenware, on which the chloride collects in the solid state. If clay containing a considerable proportion of iron is used in the preparation, it must first, after ignition with carbonaceous matter—whereby the iron is reduced to the metallic state—be treated with a dilute acid to dissolve out the iron, then washed and dried.

Chloride of aluminium is a transparent waxy substance having a crystalline structure like talc. It is colourless when pure, but generally exhibits a yellow colour, due

a. It is fusible in large masses, and according to
small quantity volatilises immediately when heated.
of hydrochloric acid. It is decomposed at a heat
odium, aluminium being set free. When it is dis-
sulphurous anhydride and chlorine are given off and
(H. Rose.)

$$SO^3 = Al^2(SO^4)^3 + 3SO^2 + 6Cl.$$

deliquescent, and dissolves readily in water. The
warm dry place, yields the hydrated chloride Al^2Cl^6.
e same solution is formed by dissolving alumina in
rous chloride cannot be obtained by heating the
latter is thereby resolved into alumina and hydro-

odium, $2NaCl.Al^2Cl^6$, is obtained by fusing together
roper proportions; by passing the vapour of chloride
e of sodium; or by adding the proper quantity of
of alumina or aluminiferous matter and carbon used
aluminium, and igniting the mass in an atmosphere
id, and condensing the vapour in the same manner as
is a crystalline mass which melts at 200° C., and
rfectly colourless when pure, much less deliquescent
being quite fixed at ordinary temperatures, may be
qualities render it much more convenient than the
on of aluminium. When ignited with sodium, it
tity (14 p. c.) of aluminium.

Al^2F^6, is produced by the action of gaseous fluoride of
luct is at first mixed with reduced silicon, but this
ion with a mixture of hydrofluoric and nitric acids.
ains in a colourless mass of cubical crystals, which
It volatilises at a bright red heat, is insoluble in
ll acids. (Deville, Compt. rend. xlii. 49.)
otassium, $6KF.Al^2F^6$, is obtained as a gelatinous pre-
f fluoride of aluminium into a solution of fluoride of
in only slight excess. A precipitate of similar cha-
F^6, is obtained by stirring up a solution of fluoride of
oride of potassium not quite sufficient for complete
ry up to white powders, and give off the whole of
l when heated with sulphuric acid. (Berzelius.)
Sodium, $6NaF.Al^2F^6$.—Found native as *Cryolite*, and
hydrofluoric acid in excess on a mixture of calcined
m in the proportions indicated by the formula, then
Cryolite belongs to the quadratic or dimetric sys-
sparent, softer than felspar, of specific gravity 2·96,
s an opaque glass on cooling: so likewise does the
ound in large quantity at Evigtok in Greenland, but
ed in any other locality. It is used, as already
aluminium, and also in Germany for the manufacture
s.

^{6}, is obtained by heating the metal with iodine or iodide
r repeated sublimation over metallic aluminium, it
ass, which melts at about 185° C., and boils at a tem-
of mercury. It resembles the bromide in most of its
the hydrate $Al^2I^3.6H^2O$, which may also be obtained
in hydriodic acid. It forms double salts with the
monia, forming a snow-white powder. It does not
phuric acid. (Weber, Pogg. Ann. cvii. 264.)

lumina, Al^2O^3.—This, which is the only known
y the direct combination of the metal with oxygen.
te does not oxidise, even at a strong red heat;
rns brightly when heated to redness in the air or in
to alumina, 53·3 pts. of the metal taking up 46·69
of alumina. The atomic constitution of alumina
or any other direct experiment, because there is no
hich to compare it; but it is inferred to be a sesqui-

oxide, because it is isomorphous with the sesquioxides of iron and chromium, and is capable of replacing those oxides in combination in any proportion.

Alumina occurs native, and very nearly pure, in the form of *corundum*, varieties of which, distinguished chiefly by their colour, are the *sapphire*, *ruby*, *oriental topaz*, *oriental amethyst*, &c. The colourless variety is called *hyaline corundum*. The crystalline forms of these gems all belong to the rhombohedral or hexagonal system, the primary form being a rather acute rhombohedron. Alumina in the crystalline state has a specific gravity of about 3·9, and is, next to the diamond, the hardest substance known. An opaque variety of corundum called *emery*, which has a brown-red colour, arising from oxide of iron, is much used in the state of powder for polishing glass and precious stones.

Alumina is prepared artificially: 1. By precipitating a boiling solution of common alum (sulphate of aluminium and potassium), free from iron, with carbonate of ammonium, washing the precipitate with water, and igniting it to expel the combined water.—2. By igniting sulphate of aluminium or ammonia-alum. In the former case, sulphuric anhydride is given off; in the latter, that compound, together with sulphate of ammonium, and alumina remains:

$$Al^2.3SO^4 = Al^2O^3 + 3SO^3$$

$$\text{and} \qquad 2(Al'''.NH^4.2SO^4) = Al^2O^3 + (NH^4)^2.SO^4 + 3SO^3.$$

Alumina thus prepared is apt however to retain a small quantity of sulphuric acid, and if the original salt contained iron, the whole of that impurity remains in the residue.—3.* By digesting clays, felspathic rocks, or other minerals containing alumina in a strong solution of caustic potash or soda, assisting the action, if necessary, by boiling under pressure, or by heating the same minerals with kelp or soda-ash in a reverberatory furnace, and lixiviating the fused product with water. A solution of aluminate of potassium or sodium is thus obtained, a silico-aluminate of the alkali generally remaining undissolved—and the alumina may be precipitated from the solution as a hydrate by passing carbonic acid through the liquid; by treating it with acid carbonate of sodium, or with neutral or acid carbonate of ammonium; by saturating with an acid (using by preference the last vapours of hydrochloric acid evolved in the manufacture of that compound); by treating it with chloride of ammonium, whereupon, ammonia is evolved, chloride of potassium or sodium remains in solution, and alumina is precipitated; or by mixing the solution of the alkaline aluminate with chloride of aluminium, the result being the precipitation of the alumina from both compounds:

$$\underbrace{Al'''K^3O^3}_{\text{Aluminate of potassium.}} + Al'''Cl^3 = Al^2O^3 + 3KCl.$$

4. By mixing cryolite with rather more than $\frac{3}{4}$ of its weight of quick lime, adding a small quantity of water to slake the lime, then a larger quantity, and heating the mixture by a current of steam. The products of this operation are fluoride of calcium and aluminate of sodium:

$$\underbrace{Al'''Na^3F^6}_{\text{Cryolite.}} + 3CaO = 3CaF^2 + \underbrace{Al'''Na^3O^3}_{\text{Aluminate of sodium.}}$$

The aluminate of sodium is decanted from the heavy deposit of fluoride of calcium, and decomposed by carbonic acid as above. If any insoluble aluminate of calcium should be formed, it may be decomposed by digestion with carbonate of sodium. (Deville.) 5. The slag obtained in the preparation of aluminium from chloride of aluminium and sodium, with fluor-spar or cryolite as a flux (p. 150), contains about 40 per cent. of fluoride of aluminium, together with soluble chlorides; and the residue of the extraction of sodium by Deville's process (see SODIUM), which consists in igniting a mixture of carbonate of sodium, carbonaceous matter and chalk, contains about 14·5 p. c. carbonate of sodium, 8·3 p. c. caustic soda, and 29·8 p. c. carbonate of calcium. Now, by heating to redness a mixture of 5 or 6 pts. of the sodium-residue with 1 pt. of the aluminium-slag, freed by washing from the soluble constituents, and lixiviating the product after cooling, a solution of aluminate of sodium is obtained which may be decomposed by carbonic acid as above. (Deville.)

Alumina prepared by any of the preceding processes contains iron. From this it may be purified by dissolving it in caustic alkali and precipitating the iron by a stream of sulphuretted hydrogen (Deville). It may then be reprecipitated by carbonic acid. The alumina thus precipitated always contains a certain quantity of

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[*] This process, the invention of M. Le Chatelier of Paris, is patented in this country in the name of H. F. Newton, 1858, No. 1988, and 1859, No. 957.

t be removed by washing with water. It may, how-
with the aid of heat, in a small quantity of dilute
by digestion with chloride of aluminium in excess.

is white, and if it has been exposed only to a moderate
t to the touch; but after strong ignition, it cakes
arcely to be scratched with a file, and emits sparks
ing to H. Rose (Pogg. Ann. lxxiv. 430), the specific
r a spirit-lamp is between 3·87 and 3·90; after six
, it is between 3·725 and 3·75; and after ignition in a
agrees very nearly with that of native corundum.
aperatures below that of the oxy-hydrogen flame; but
into transparent globules which assume a crystalline
l quantity of chromate of potassium be added before
ooling retains a deep red colour, and resembles the
of 1 pt. of alumina and 3 or 4 pts. of anhydrous
ble time to the high temperature of a porcelain fur-
ne fused borax, and as the borax is volatilised by the
ling corundum; in this case also, the addition of a
of potassium causes the crystals to exhibit the colour
plicable to the artificial formation of a great number
men, Ann. Ch. Phys. [3] xxii. 211.)
by heat alone. Potassium at a white heat deoxidises
potassium and aluminium which decomposes water.
at any temperature, unless it be mixed with charcoal,
ninium is produced.
ly insoluble in water. After strong ignition, it is like-
ncentrated hydrochloric or sulphuric acid being alone
tallised state it is insoluble in all acids. It may, how-
s by fusion with hydrate of potassium or sodium.
r OF ALUMINA. These compounds are three in num-

. . . $Al^2H^2O^4$ or $Al^2O^3.H^2O$.
. . . $Al^2H^4O^5$ „ $Al^2O^3.2H^2O$.
. . . $Al^2H^6O^6$ „ $Al^2O^3.3H^2O$.

tive as *Diaspore*, a mineral which forms translucent
vity 3·43, and crumbles to powder when heated, but
its water below 360° C. It is insoluble in water, and
id.
y gelatinous precipitate, obtained by treating solutions
ample, with ammonia or alkaline carbonates; it is also
utions by sulphide of ammonium, the aluminium not
the sulphur. When dried at a moderate heat, it forms
eres to the tongue and forms a stiff paste with water,
quid. At a strong red heat, it parts with its water, and
ion of volume. It dissolves with great facility in acids,
s. When a solution of alumina in caustic potash is
absorbs carbonic acid, and the trihydrate of aluminium
tals which are but sparingly soluble in acids.
has a very powerful attraction for organic matter, and
vegetable colouring matter, combines with and carries
hich is thus removed entirely from the liquid if the
y. The pigments called *lakes* are compounds of this
mpregnated with alumina acquires the same power of
ence the great use of aluminous salts as *mordants* to
EING.)
urs native as *Gibbsite*, a stalactitic, translucent, fibrous
ds.
H^4O^5, or $Al^2O^3.2H^2O$.—When a dilute solution of diace-
several days to a temperature of 100° C. in a close vessel,
t free, although no precipitation of alumina takes place.
f acetic acid, and if afterwards boiled in an open vessel,
ts acetic acid, the alumina nevertheless remaining in
gulated by mineral acids and by most vegetable acids,
f dye-woods. The alumina contained in it is, however,
s a mordant. Its coagulum with dye-woods has the

colour of the infusion, but is translucent and totally different from the dense opaque lakes which ordinary alumina forms with the same colouring matters. On evaporating the solution to dryness at 100° C. the alumina remains in the form of dihydrate, retaining only a trace of acetic acid. In this state, it is insoluble in the stronger acids, but soluble in acetic acid, provided it has not been previously coagulated in the manner just mentioned. Boiling potash converts it into the trihydrate (Walter Crum, Chem. Soc. Qu. J. vi. 225). The dihydrate is said to occur native at Béaux (Berthier, Schw. J. xxxiv. 154). *Hydrargyllite*, a mineral occurring in regular six-sided prisms is also a hydrate of aluminium, but its exact composition is not known. (G. Rose, Pogg. Ann. xlviii. 564; l. 656.)

Aluminates.—The hydrogen in trihydrate of aluminium, may be replaced by an equivalent quantity of various metals; such compounds are called *aluminates*. According to Frémy, a solution of alumina in potash slowly evaporated [out of contact of air?] deposits granular crystals of aluminate of potassium, $Al^2K^2O^4$, or $Al^2O^3.K^2O$. Similar compounds occur native; thus *Spinell* is an aluminate of magnesium, $Al^2Mg''O^4$; *Gahnite*, an aluminate of zinc, $Al^2Zn''O^4$.

Oxygen-Salts of Aluminium.—The general characters of these salts have already been described (p. 154). The most important of them are the sulphate $Al^2(SO^4)^3$, with its double sulphates, especially common alum, the sulphate of aluminium and potassium, and the silicates and double silicates. [For the detailed descriptions of these salts, see the several Acids.]

Phosphide of Aluminium.— Obtained by heating pulverulent aluminium to redness in phosphorus vapour. It is a dark grey mass, which acquires metallic lustre by burnishing, and is decomposed by water, with evolution of non-spontaneously inflammable phosphoretted hydrogen. (Wöhler.)

Silicide of Aluminium.—Aluminium combines readily, and in all proportions, with *silicon*. When strongly heated in contact with any silicious substances, such as glass or porcelain, it reduces the silicon and unites with it. Nevertheless aluminium may be fused in glass or earthen vessels, without undergoing the slightest alteration, provided no flux be used, because it does not then come into intimate contact with the substance of the vessel; but the addition of a flux produces instant decomposition. The properties of the compound vary with the proportion of silicon. An alloy containing 10·3 per cent. of silicon, called *cast* aluminium (*fonte d'aluminium*) is grey and very brittle. A compound containing 70 per cent. silicon, still exhibits metallic properties. All the compounds of aluminium and silicon are much more easily altered by exposure to the air, or by the action of acids and alkalies, than either pure aluminium or pure silicon.

Selenide of Aluminium, Al^2Se^3.—Produced with incandescence when aluminium is heated in selenium vapour. It is a black powder, which acquires a dark metallic lustre by burnishing, and is readily decomposed by water or by a moist atmosphere, with formation of alumina and hydroselenic acid.

Sulphide of Aluminium, Al^2S^3.—Sulphide may be distilled over aluminium without combining with it; but when thrown upon the red-hot metal, it is absorbed with vivid incandescence (Wöhler). The sulphide may be prepared by passing the vapour of disulphide of carbon over red-hot alumina. It is fusible, decomposes water at ordinary temperatures, yielding hydrate of aluminium and hydrosulphuric acid, and thus perhaps contributes to the formation of natural sulphur springs. (Frémy.)

ALUMO-CALCITE. A mineral from Erbenstock, in the Saxon Harz, having the appearance of opal. Specific gravity 2·1 to 2·2, scarcely harder than mica. Contains, according to Kersten's analysis, 6·25 per cent. lime, 2·23 alumina, and 40 water. It is probably a mere residue of decomposition.

ALUM-EARTH. A massive variety of aluminous schist, found in the neighbourhood of tertiary lignites, as in several parts of the valley of the Oder, on the Rhine, in Picardy, and other localities. It has not a distinct slaty structure, but is a soft, friable, usually dark brown mass.

ALUM-SLATE. A clay slate, containing bitumen and sulphide of iron, generally found in the transition-strata, but sometimes in more recent formations. It is found in the north of England and in Scotland, in Scandinavia, in the Harz, in the Ural, the Vosges, the lower Rhine, and other localities. There are two varieties of it, viz. 1. *Common.* This mineral occurs both massive and in insulated balls of a greyish-black colour, dull lustre, straight slaty fracture, tubular fragments, streak coloured like itself. Though soft, it is not very brittle. Effloresces, acquiring the taste of alum.

2. *Glossy Alum-slate.* A massive mineral of a bluish-black colour. The rents display a variety of lively purple tints. It has a semi-metallic lustre in the fracture,

lulating. There is a soft variety of it, approaching in
xposure to air its thickness is prodigiously augmented
loresence, which separates its thinnest plates. These
ections, causing entire disintegration.

TONE. A basic sulphate of aluminium and potas-
or $\begin{matrix}K^2O\\Al^2O^3\end{matrix}\Big\{4SO^3 + 3(Al^2O^3.3H^2O)$, found chiefly in vol-
ar Civita Vecchia, at Solfatara, near Naples, at Puy de
localities. Used for the preparation of Roman alum.
llised; the former is usually greyish white, and some-
ily frangible, scratches calcareous spar, but is scratched
generally situated in the cavities of the massive sub-
sometimes externally brownish, their form is an obtuse
The crystals have the composition above given: the
ition a considerable quantity of silica.

phate of aluminium. (See SULPHATES.)

ion of mercury with another metal. (See MERCURY.)

ne process of extracting gold and silver from their ores
rcury. (See GOLD and SILVER.)

αλός, *soft*, on account of its feeble acid reaction.)—A
f caffeine by chlorine (see CAFFEINE), discovered by
that of alloxantin having the whole of its hydrogen
$^4O^7 + H^2O$.
s crystals, which do not give off their water at 100° C.
lts and volatilises, leaving scarcely a trace of charcoal,
lding an oil and crystallised body. It slightly reddens
on the skin, imparting to it an unpleasant odour, like
lts like alloxantin. Nitric acid converts it into a crys-
sed to vapour of ammonia, it gradually assumes a deep
npound which dissolves in water with the colour of
crystalline body, to which Rochleder gives the name
sh, and soda, it forms compounds of a deep violet

ic base obtained by Letellier from the fly agaric (*Agari-
ria*), and from *Agaricus bulbosus*, and supposed by him
these agarics. According to Apaiger and Wiggers, on
contains a peculiar acid (muscaric acid), as well as a
he poisonous action is due. (Handw. d. Chem. 2^{te} Aufl.

zoline, Pikramin, Hydrure d'azobenzoiline.—(Laurent,
wnes, Ann. Ch. Pharm. liv. 363; Gössmann, Ann.
i. 193.)
ed simultaneously by Laurent and by Fownes. It is
from which it is generally prepared. 1. When hydro-
r four hours to 120°—130° C., the vitreous mass, when
l, and excess of hydrochloric acid added, white crystals
eparate out (Bertagnini). — 2. Hydrobenzamide is
stic potash, the resulting resin dissolved in dilute sul-
pitated by ammonia, and the precipitate washed with
alcohol (Fownes). — 3. A solution of bitter-almond
with gaseous ammonia, solidifies in 24—48 hours into
oiled with water, and saturated while hot with hydro-
tance separates out, together with crystals of a peculiar
he hot solution is decanted, and the residue again
ntil all the hydrochlorate of amarine is dissolved out.
y ammonia; and the precipitate is washed, dissolved in
drochloric acid, and reprecipitated by ammonia: pure
(Laurent). — 4. When the dry compound of bitter-
ammonium is heated in a large retort to 180°—200°
of slaked lime, amarine and lophine distil over. The
the receiver, partly in the lower part of the neck of
ol, and purified as in the former process. (Gössmann.)
cohol in shining six-sided prisms. It melts at 100° C.
s on cooling: when heated more strongly, it volatilises

almost completely, ammonia being evolved: an oil smelling like benzol distils over, and a sublimate collects in the neck of the retort, which Fownes calls *pyrobenzoline*, and which, according to Laurent, is identical with lophine. Amarine is inodorous, tasteless at first, but afterwards slightly bitter. It is insoluble in water, soluble in alcohol and ether; the alcoholic solution is strongly alkaline. Amarine becomes strongly electrical by friction. Unlike its isomer, hydrobenzamide, it exerts a poisonous action on animals.

Amarine is readily attacked by bromine, hydrobromate of amarine being formed together with a resinous mass. When it is boiled with a mixture of sulphuric and chromic acids and water, a brisk action takes place, and benzoic acid is abundantly formed. Nitric acid acts similarly, but less violently. Fused potash does not attack it, save at a very strong heat.

Amarine-salts are formed by the direct combination of amarine with acids. With the exception of the acetate, they are all but slightly soluble. The *hydrochlorate*, $C^{21}H^{18}N^2.HCl$, crystallises in small shining needles, which effloresce in vacuo, or when heated to 100°. When hydrochloric acid is poured upon amarine, a colourless oil is formed, which gradually solidifies on drying, and may be drawn into threads when heated. It distils without decomposition, passing over as an oil which solidifies to a transparent mass. It is soluble in alcohol and ether. The *chloroplatinate* separates in yellow needles, when boiling alcoholic solutions of the hydrochlorate and of dichloride of platinum are mixed together. Fownes found in it 19·8 per cent. platinum; the formula $2(C^{21}H^{18}N^2.HCl).PtCl^4$ requires 19·58 per cent. The *sulphate* crystallises from an acid solution in small colourless prisms resembling oxalic acid. The *nitrate* is obtainde by treating amarine with hot dilute nitric acid; a soft, amorphous mass is produced, which dissolves in boiling water, and on cooling deposits small crystals, which remain unaltered in vacuo. The *acetate* is very soluble, and yields on evaporation a gummy non-crystalline mass.

Diethylamarine, $C^{21}(C^2H^5)^2H^{16}N^2$. — Amarine heated with iodide of ethyl, yields a crystalline salt, which is the hydriodate of this base. The base itself is obtained by distilling the hydriodate with potash. It crystallises readily in oblique rhombic prisms, is nearly insoluble in water, but dissolves readily in alcohol and ether. It melts between 110° and 115° C. but does not solidify again till cooled down to 70°. At a stronger heat it decomposes. The *hydrochlorate* crystallises in oblique rhombic prisms. The *platinum-salt* is a yellow powder, insoluble in water and in ether, but soluble in alcohol, from which it crystallises in small prisms. (Borodine, Ann. Ch. Pharm. cx. 78.)

Diethylamarine treated with iodide of ethyl yields the hydriodate of another crystalline base, probably triethylamarine, which however has not yet been analysed, and this base again treated with iodide of ethyl, yields a third crystalline base. (Borodine.)

Trinitramarine, $C^{21}H^{15}(NO^2)^3N^2$ (Bertagnini, Ann. Ch. Pharm. lxxix. 275).— This compound is formed from trinitrohydrobenzamide, with which it is isomeric, just as amarine is from hydrobenzamide. Trinitrohydrobenzamide is boiled with 1 vol. caustic potash of 46° Baumé, and 50 vols water; the resulting brown resinous mass (which becomes brittle on cooling) is dissolved in hot alcohol; a little ether added; and the solution is precipitated by hydrochloric acid. The hydrochlorate is redissolved in alcohol, alcoholic ammonia added to the solution, and the precipitated trinitramarine is washed with water, and recrystallised from alcohol. Trinitramarine is also obtained by heating trinitrohydrobenzamide in an oil-bath to 125°—130° C.

It crystallises slowly from its alcoholic solution in white hard nodules. It melts in boiling water, and dissolves slightly, forming an alkaline solution. It is soluble in boiling alcohol or ether, most readily in a mixture of the two. A hot saturated solution deposits it on cooling as an amorphous powder.

Its salts are but slightly soluble in water. The *hydrochlorate* separates in small shining needles when hydrochloric acid is added to an alcoholic solution of trinitramarine; it is nearly insoluble in cold, slightly soluble in boiling alcohol. The *nitrate* crystallises in needles from boiling alcohol. An alcoholic solution of trinitramarine forms with *dichloride of platinum*, small, yellow, heavy nodules insoluble in alcohol; and with *mercuric chloride*, a somewhat crystalline precipitate.—F. T. C.

AMARONE. $C^{16}H^{11}N$ (Laurent, Rev. Scient. xviii. 207, &c).—A compound formed by the dry distillation of azobenzoyl, benzoylazotide, or hydrobenzamide. The sublimate obtained by heating benzoylazotide is washed with ether, and then freed from lophine by boiling in alcohol containing hydrochloric acid; the residue is washed with alcohol, dried, crystallised from boiling rock-oil, and washed with ether. It forms small, colourless, inodorous needles, which melt at 233° C., and solidify to a radiated mass on cooling. It is insoluble in water, slightly soluble in alcohol, more readily in ether. It dissolves in cold sulphuric acid, with a fine blood-red colour, which dis-

the amarone separating out. It dissolves sparingly in
s unchanged on cooling. It is not decomposed by boiling
C.

n by Laurent to a substance which he afterwards found
.

with ERYTHRIN-BITTER or PICRO-ERYTHRIN.

ISAMIDE.

FELSPAR.

variety of orthoclase, coloured green by copper. It is
Lake Ilmen in Russia, also in Norway. It is used for

um, Ambra flava, Bernstein, Agtstein, gelbes Erdharz.—
nce, sometimes perfectly transparent, but mostly semi-
a glassy surface; it is found of all colours but chiefly
ntains leaves or insects. Its specific gravity varies from
5; slightly brittle; fracture conchoidal. It is susceptible
electric by friction: hence the word electricity (from
ed or heated, it emits a peculiar smell. It is insoluble
he latter, when highly rectified, extracts a reddish colour
huric acid, to which it imparts a reddish purple colour,
n of water. No other acid dissolves it, nor is it soluble
ithout decomposition; but pure alkalis dissolve it.
er contains a volatile oil, succinic acid, and two resins
According to Schroetter and Forchammer, amber when
uble constituents, possesses the composition of camphor

er presents three distinct phases, characterised by the
n submitted to the action of heat, amber softens, fuses,
gives off succinic acid, water, oil, and a combustible
ophony of Amber) be more strongly heated, a colourless
the residue is completely charred, and the heat is raised
ellow substance sublimes of the consistence of wax.
xture of several hydrocarbons. The more volatile portion
° and 260° C., is decomposed in the cold by sulphuric acid,
ric acid, and by chlorine; the less volatile portion produced
begins to boil at 140°, and then rises to 300°; sulphu-
l chlorine do not alter it. According to Pelletier and
] ix. 89), these oils present the composition of oil of
r cent. of carbon, and 11·3 of hydrogen.
two oils is used in pharmacy under the name of oil of
he constituents of *Eau de Luce*, a preparation sometimes
s of venomous animals, and consisting of 1 part of oil
6 of caustic ammonia.
asses over in the dry distillation of amber is a mixture
rystalline substance, and a brown bituminous substance;
treatment with ether and alcohol. The yellow matter
chrysene (C 94·4, H 5·8). It is scarcely soluble in
s pulverulent rather than crystalline, and requires for
C.
ene) is tasteless and inodorous, it is scarcely soluble in
e in ether, but more soluble than the yellow matter; it
°, and distils above 300°. Nitric acid resinises it
ording to Pelletier and Walter, 95·6 per cent. of carbon

th fuming nitric acid, a resin is formed (artificial musk)
of nitric acid, and contains $C^{15}H^{16}N^{2}O^{2}$.
listilled with a strong solution of potash, a watery liquid
hite substance which exhibits all the properties of com-

egular veins in some parts of Prussia, especially between
nicken. In East and West Prussia there is scarcely a
found. and thence it extends into Mecklenburg and Hol-
ole Baltic plain. It has likewise been found in southern
pain, Sweden and Norway; also on the shores of the

Caspian, in Siberia, Kamtschatka, China, Hindoostan, Madagascar, North America and Greenland. In Britain it is thrown out by the sea on the shores of Norfolk, Suffolk and Essex, and has also been found in the sands at Kensington. In the Royal Cabinet at Berlin there is a mass of 18 lbs. weight, supposed to be the largest ever found.

Haüy has pointed out the following characters by which amber may be distinguished from mellite and copal, the bodies which most closely resemble it. Mellite is infusible by heat; a bit of copal heated at the end of a knife takes fire, melting into drops, which flatten as they fall; whereas amber burns with spitting and frothing, and when its liquefied particles drop, they rebound from the plane which receives them.

Various frauds are practised with this substance. Neumann states as the common practices of workmen the two following: The one consists in surrounding the amber with sand in an iron pot, and cementing it with a gradual fire for forty hours, some small pieces placed near the sides of the vessel being occasionally taken out for judging of the effect of the operation. The second method, which he says is that most generally practiced, is to digest and boil the amber about twenty hours with rapeseed oil, by which it is rendered both clear and hard.

The chemical properties and mode of occurrence of amber leave no doubt of its being the produce of extinct coniferæ. It has been found encrusting or penetrating fossil wood exactly like resin at the present day, and enclosing the cones and leaves of the trees. Numerous insects, the inhabitants of these ancient forests have been embalmed in it. To the tree which principally produced it, Göppert gives the name of *Pinites succinifer*, but there was probably more than one species. Amber is often stated to occur in the brown coal beds of Northern Germany, but Göppert states that he knows of no instance of this, the substance found in those beds being retinite. (Handw. d. Chem. 2te Aufl. ii. 972; Dana, ii. 466; Gerh. iv. 394).

AMBERGRIS. (*Ambra*, *Ambra grisea*), is found in the sea, near the coasts of various tropical countries; and has also been taken out of the intestines of the spermaceti whale (*Physeter macrocephalus*). As it has not been found in any whales but such as are dead or sick, its production is generally supposed to be owing to disease, though some have a little too positively affirmed it to be the cause of the morbid affection. As no large piece has ever been found without a greater or smaller quantity of the beaks of the *sepio octopodia*, the common food of the spermaceti whale, interspersed throughout its substance, there can be little doubt of its originating in the intestines of the whale: for if it were merely occasionally swallowed by the animal, and then caused disease, it would much more frequently be without these bodies, when it is met with floating in the sea, or thrown upon the shore.

Ambergris is found of various sizes, generally in small fragments, but sometimes so large as to weigh near two hundred pounds. When taken from the whale, it is not so hard as it afterwards becomes on exposure to the air. Its specific gravity ranges from 0·780 to 0·926. If good, it adheres like wax to the edge of a knife with which it is scraped, retains the impression of the teeth or nails, and emits a fat odoriferous liquid on being penetrated with a hot needle. It is generally brittle; but, on rubbing it with the nail, it becomes smooth, like hard soap. Its colour is either white, black, ash-coloured, yellow, or blackish; or it is variegated, namely, grey with black specks, or grey with yellow specks. Its smell is peculiar, and not easy to be counterfeited. At 62·2 C. it melts, and at 100 C. is volatilised in the form of a white vapour; on a red-hot coal it burns, and is entirely dissipated. Water has no action on it; acids, except nitric acid, act feebly on it; alkalis combine with it, and form a soap; ether and the volatile oils dissolve it; so do the fixed oils, and also ammonia, when assisted by heat; alcohol dissolves a portion of it.

The principal constituent of ambergris is ambrein (*q. v.*) Succinic and benzoic acids are said to be sometimes found among the products of its destructive distillation. Its inorganic constituents are carbonate and phosphate of calcium, with traces of ferric oxide and alkaline chlorides.

An alcoholic solution of ambergris, added in minute quantity to lavender water, tooth powder, hair powder, wash balls, &c. communicates its peculiar fragrance. Its retail price being in London a guinea per oz. leads to many adulterations. These consist of various mixtures of benzoin, labdanum, meal, &c. scented with musk. The greasy appearance and smell which heated ambergris exhibits, afford good *criteria*, joined to its solubility in hot ether and alcohol.

It has occasionally been employed in medicine, but its use is now confined to the perfumer. Swediaur took thirty grains of it without perceiving any sensible effect. — U.

AMBLYGONITE. A greenish-coloured mineral of different pale shades, marked on the surface with reddish and yellowish-brown spots. It occurs massive and crystallised in oblique four-sided prisms. Lustre vitreous; cleavage parallel to the sides of an oblique four-sided prism of 106° 10′ and 77° 50′; fracture uneven; fragments rhomboidal; translucent; hardness as felspar; brittle; specific gravity 3·0: intumesces

with a reddish-yellow phosphorescence into a white
, with green topaz and tourmaline, at Chursdorf and
ny. A specimen from Arsndorf analysed by Rammelsberg
ride, 88·43 alumina, 7·03 lithia, 3·29 soda, 0·43 potash.
y nearly with the formula:

$$O^5 + 5M^2O.3P^2O^5) + Al^2F^6 + 2MF.$$

i. 665; Dana, ii. 409.)

g ambergris in hot alcohol, specific gravity 0·827, the
ein by Pelletier and Caventou, is obtained. The alcohol,
in in very bulky and irregular crystals which still retain
alcohol. Thus obtained, it has the following properties:
lour, has an agreeable odour, of which it is deprived by
lisation. It is destitute of taste, and does not act on
le in water, but dissolves readily in alcohol and ether;
in these liquids when hot than when cold. It melts at
° C. When heated above 100° C., it is partly volatilised
white smoke. It does not seem capable of combining
aponified. When heated with nitric acid, it becomes
ates nitrous gas, and is converted into an acid, which
This acid is yellowish white, has a peculiar odour,
not melt at 100° C., and does not evolve ammonia
emperatures. It is soluble in alcohol and ether; but
te of potassium forms yellow precipitates with chloride
n, nitrate of silver, acetate of lead, corrosive sublimate,
de of gold. (J. Pharm. v. 49.)
cholesterin, which substance it greatly resembles in its
. Ch. Pharm. vi. 24) found it to contain 83·3 p. c. C,
nearly the composition of cholesterin: if this be so,
ical with cholesteric acid.

applied to the ethers of the amic acids, *e. g.* oxamethane
ic Acids.)

thyst is a gem of a violet colour, and great brilliancy,
or sapphire, from which it differs only in colour. This
t, and is very rare. When it inclines to the purple or
d than when it is nearer to the blue. These amethysts
ss, specific gravity, and other qualities, as the best sap-
om the same places, particularly from Persia, Arabia,
. The occidental amethysts are merely coloured crystals
and Sapphire.)

iety of Hornblende (*q. v.*)

in flax. (See Asbestos.)

name are designated a class of nitrogenised acids, which
n-salts of polybasic acids by the elements of one or more
nder certain circumstances, are capable of taking up the
rating ammonia and the original non-nitrogenised poly-
iderable resemblance to amides in their modes both of
ion: but they differ from these bodies in possessing
operties, and in not deriving from the type NH^3.
titution, amic acids are best regarded as deriving from
They represent this type in which 2, 3, or 4 atoms of
r radicles, one of which must be the radicle of a *polybasic*
d into 3 classes, according as 2, 3, or 4 atoms of hydrogen
therefore, it is obvious that 2 atoms of hydrogen in
y 1 diatomic acid radicle; in class 2, three atoms of
triatomic, or by 1 diatomic and 1 monatomic acid radicle;
ormed by the substitution of an acid radicle of less than
pe: if 1 atom of hydrogen in NH^3,H^2O be replaced by
d, the only result is the formation of the ammonium-salt

$$\underset{\text{Acetyl.}}{(C^2H^3O)}HO = \underset{\text{Acetate of ammonium}}{C^2H^3O.NH^4.O}$$

Neither can an amic acid be formed by replacing 2 atoms hydrogen in the type by 2 monatomic acid radicles; for when benzoic anhydride is treated with ammonia, the 2 atoms of benzoyl, each equivalent to H, do not remain combined, forming an amic acid, but separate, forming 2 distinct compounds, benzamide and benzoate of ammonium:

$$\underset{\text{Benzoic anhyd.}}{(C^7H^5O)^2.O} + 2NH^3 = \underset{\text{Benzamide.}}{N.C^7H^5O.H^2} + \underset{\text{Benzoate of amm.}}{C^7H^5O.NH^4.O}$$

But when a dibasic anhydride is treated with ammonia, the acid radicle, equivalent to H^2, being indivisible, is incapable of separating so as to form two distinct compounds; so that a single compound is necessarily formed, the ammonium-salt of an amic acid:

$$\underset{\text{Sulphuric anhyd.}}{SO^2.O} + 2NH^3 = \underset{\text{Sulphamate of amm.}}{N\overbrace{H^2.S}^{'''}\overbrace{O^2.H}^{''}.O}$$

Hence it follows that a monobasic acid is incapable of forming an amic acid: in fact the possession of this property is perhaps one of the most distinguishing characteristics of polybasic acids.

We now proceed to describe the modes of formation, properties, and reactions of amic acids, dividing them into 3 classes, according as 2, 3, or 4 atoms of hydrogen are replaced in the type.

Class 1. They represent the type $N\overbrace{HHH}^{'''}\ \overbrace{HH}^{''}O$ in which 2 atoms of hydrogen are replaced by one diatomic acid radicle:

Sulphamic acid	$N\overbrace{H.H.S}^{'''}\overbrace{O^2.H}^{''}.O$
Carbamic acid	$N\overbrace{H.H.C}^{'''}\overbrace{O.H}^{''}.O$
Oxamic acid	$N\overbrace{H.H.C^2}^{'''}\overbrace{O^2.H}^{''}.O$
Succinamic acid	$N\overbrace{H.H.C^4H^4}^{'''}\overbrace{O^2.H}^{''}.O$

They are formed—1. By action of heat on the acid ammonium-salt of a dibasic acid:

$$\underset{\text{Acid oxalate of amm.}}{C^2O^2.(NH^4)H.O^2} - H^2O = \underset{\text{Oxamic acid.}}{N.\overbrace{H^2.C^2}^{'''}\overbrace{O^2.H}^{''}.}$$

In some cases, *e. g.* comenamic acid, $NH^2.C^6H^2O^3.H.O$, prolonged boiling of the ammonium-salt with water is sufficient.

2. By action of ammonia on anhydrides:

$$\underset{\text{Camphoric anhyd.}}{C^{10}H^{14}O^2.O} + NH^3 = \underset{\text{Camphoramic acid.}}{N\overbrace{H^2.C^{10}H^{14}}^{'''}\overbrace{O^2.H}^{''}.O}$$

The best mode is to dissolve the anhydride in absolute alcohol, and to lead dry ammonia into the solution. The reaction takes place with 2 atoms of ammonia, an amate of ammonium being formed.

3. By action of ammonia on acid salts of organic radicles:

$$\underset{\substack{\text{Acid salicylate of methyl.}\\\text{(Methyl-salicylic acid.)}}}{C^7H^4O.(CH^3)H.O^2} + NH^3 = \underset{\text{Salicylamic acid.}}{N\overbrace{H^2.C^7H^4}^{'''}\overbrace{O.H}^{''}.O} + \underset{\substack{\text{Methylic}\\\text{alcohol.}}}{CH^3.H.O}$$

4. By action of aqueous ammonia on ethers of dibasic acids. (Gerhardt, Chim. org. iv. p. 668.)

$$C^{10}H^{16}O^2.(C^2H^5)^2.O^2 + NH^3 + H^2O = \underset{\text{Sebamic acid.}}{N\overbrace{H^2.C^{10}H^{16}}^{'''}\overbrace{O^2.H}^{''}.O} + 2\left(\underset{\text{Alcohol.}}{C^2H^5.H.O}\right)$$

5. Imides, boiled with dilute ammonia, take up H^2O, and form amic acids: some alkalamides exhibit the same reaction:

$$\underset{\text{Succinimide.}}{N.C^4H^4O^2.H} + H^2O = \underset{\text{Succinamic acid.}}{N\overbrace{H^2.C^4H^4}^{'''}\overbrace{O^2.H}^{''}.O}$$

$$Ag. + H^2O = N\overbrace{H^2.C^4H^4}^{'''}\overbrace{O^2.Ag}^{''}.O$$

ccini- Succinamate of silver.

boiled with mineral acids or alkalis, take up H^2O, and ammonium:

$$I^4 + H^2O = N\overbrace{H^2.C^4H^4}^{'''}\overbrace{O^3.H}^{''}.O + NH^3$$

) Malamic acid. (Aspartic acid.)

ed by the action of hydrosulphuric acid on nitro-conju-

$$+ 3H^2S = N\overbrace{H^2.C^7H^4}^{'''}\overbrace{O.H}^{''}.O + 2H^2O + 3S$$

Oxybenzamic acid.

nmonly called benzamic acid; an impossible name, as Ve regard it as the amic acid of oxybenzoic acid, although it does not form acid salts. Strecker regards ic acid, $NH.C^6H^5.CO.H.O$.

ype $N\overbrace{HHH}^{'''}\ \overbrace{HH}^{''}O$ in which 3 atoms hydrogen of are re- radicle, (b) by 1 diatomic and 1 monatomic acid radicle, ionatomic basic radicle.

omic acid radicle:

.O, formed by the action of ammonia on phosphoric

$$NH^3 = 2(N.HPO.H.O) + H^2O.$$

mic and 1 *monatomic acid-radicle:*

id . . . . $N\overbrace{H.C^7H^5O.C^7H^4}^{'''}\overbrace{O.H}^{''}.O$

nic acid . . . $N\overbrace{H.C^6H^5SO^2.C^4H^4}^{'''}\overbrace{O^2.H}^{''}.O.$

rtiary amides with aqueous ammonia (Gerhardt and

$$NH^4.H.O = N\overbrace{H.C^6H^5SO^2.C^4H^4}^{'''}\overbrace{O^2.NH^4}^{''}.O.$$

Sulphophenyl-succinamate of amm.

monatomic and 1 *acid diatomic radicle:*

. . . . . $N\overbrace{H.C^2H^5.C^2}^{'''}\overbrace{O^2.H}^{''}.O$

anilic) acid . . . $N\overbrace{H.C^6H^5}^{'''}\overbrace{SO^2.H}^{''}.O$

inanilic) acid . . . $N\overbrace{H.C^6H^5}^{'''}\overbrace{C^4H^4O^2.H}^{''}.O.$

y be called *alkalamic* acids) are obtained by the same mation of acids of class 1, a primary amine being sub-

of organic alkalis:

$$H^4.O^2 - H^2O = N\overbrace{H.CH^3.C^2}^{'''}\overbrace{O^2.H}^{''}.O.$$

f me- Methyloxamic acid.

ines on dibasic anhydrides:

$$N.C^6H^5.H^2 = N\overbrace{H.C^6H^5.C^5H^6}^{'''}\overbrace{O^2.H}^{''}.O.$$

Phenylamine. Phenylpyrotartramic acid.

3. By heating alkalimides with dilute ammonia:

$$N.C^6H^5.C^4\overset{''}{H}{}^4O^3 + H^2O = NH.\overbrace{C^6H^5.C^4H^4}^{'''}\overbrace{O^3.H}^{''}.O.$$

Phenylmalamide. Phenylmalamic acid.

Class 3. They represent the type NH^3,H^2O in which four atoms of hydrogen are replaced by other radicles, one of which must be a polyatomic acid radicle. The only known members of this class are a few phenyl-compounds: phenylcitramic acid, $N.\overbrace{C^6H^5.C^6H^5}^{'''}\overbrace{O^4.H}^{''}.O$, is an example.

There are also certain nitrogenised acids, which either exist ready formed in nature, or are products of the decomposition of other compounds, which we may regard as amic acids. Thus glycocoll, $C^2H^5NO^2$, is the amic acid of glycollic acid, $C^2H^2O.H^2.O^2$, and may be written $NH^2.C^2H\,O.H.O$. Hippuric, choleic, and other acids may also be regarded as amic acids; but their constitution is as yet but imperfectly understood.

Amic acids are distinct monobasic acids: they form well defined salts, which are generally more soluble than those of the corresponding dibasic acids. They are mostly solid, crystalline, not volatile without decomposition. When heated, many of them lose the elements of 1 atom of water, and are converted into imides: others are decomposed into a dibasic anhydride and a primary amine. When boiled with mineral acids or alkalis, they mostly take up the elements of 1 atom of water, and regenerate the corresponding dibasic acid, and ammonia or a primary amine: in some cases, the mere boiling of their aqueous solutions suffices for this reaction; in others, fusion with solid potash is required:

$$NH.\overbrace{C^6H^5.C^4H^4}^{'''}\overbrace{O^2.H}^{''}.O + H^2O = C^4\overset{''}{H}{}^4O^2.H^2.O^2 + N.C^6H^5.H^2$$

Phenylsuccinamic acid. Succinic acid. Phenylamine.

With nitrous acid, many amic acids regenerate the corresponding dibasic acid, with evolution of nitrogen:

$$NH^2.\overbrace{C^4H^4}^{'''}\overbrace{O^3.H}^{''}.O + NHO^2 = C^4\overset{''}{H}{}^4O^3.H^2.O^2 + N^2 + H^2O.$$

Malamic acid. Malic acid.

Like all decided acids, amic acids form ethers, *i. e.* salts of alcohol-radicles. These amic ethers are sometimes called *urethanes* (or amethanes), the former name having been applied to the earliest discovered, carbamic ether. They are formed by the incomplete action of ammonia on the ethers of dibasic acids:

$$C^2O^2.(C^2H^5)^2.O^2 + NH^3 = \overbrace{NH^2.C^2}^{'''}\overbrace{O^2.C^2H^5}^{''}.O + C^2H^5.H.O.$$

Oxalic ether. Oxamic ether. Alcohol.

They are isomeric with alkalamic acids. When boiled with water, acids, or alkalis, they are converted into dibasic acids, alcohol, and ammonia:

$$NH^2.C^2O^2.C^2H^5.O + 2H^2O = C^2O^2.H^2.O^2 + C^2H^5.H.O + NH^3.$$

Oxamic ether. Oxalic acid. Alcohol.

Excess of ammonia converts them into primary diamides (*q. v.*)—F. T. C.

Amic Bases. This name may be given to a class of bodies produced by the action of ammonia on the oxides, or chloro- or bromo- hydrates of polyatomic alcohol-radicles, and which are related to the polyatomic alcohols in the same way as the *amic acids* to the polyatomic acids. Their leading properties may be expressed by representing them as derived from a combination of the types NH^3 and H^2O.

The following bodies belonging to this class are already known:

$$\text{Anisamine, } C^8H^{11}NO = \left.\begin{matrix}(\overset{''}{C^8}H^8)\\H^3\end{matrix}\right\}\begin{matrix}N\\O\end{matrix};\ \text{type}\left\{\begin{matrix}H^3N\\H^2O\end{matrix}\right.$$

$$\left.\begin{array}{lcl}
\text{Dianisamine, } C^{16}H^{19}NO^2 & = & \left.\begin{matrix}(\overset{''}{C^8}H^8)^2\\H^3\end{matrix}\right\}\begin{matrix}N\\O^2\end{matrix}\\
\text{Diglycolamine, } C^4H^{11}NO^2 & = & \left.\begin{matrix}(\overset{''}{C^2}H^4)^2\\H^3\end{matrix}\right\}\begin{matrix}N\\O^2\end{matrix}\\
\text{Glyceramine, } C^3H^9NO^2 & = & \left.\begin{matrix}(\overset{'''}{C^3}H^5)\\H^4\end{matrix}\right\}\begin{matrix}N\\O^2\end{matrix}\\
\text{Diglyceramine, } C^6H^{11}NO^2 & = & \left.\begin{matrix}(\overset{'''}{C^3}H^5)^2\\H\end{matrix}\right\}\begin{matrix}N\\O^2\end{matrix}
\end{array}\right]\ ;\ \text{type}\left.\begin{matrix}H^3N\\2(H^2O)\end{matrix}\right\}$$

$$\text{Triglycolamine, } C^6H^{15}NO^3 = \left.\begin{matrix}(\overset{''}{C^2}H^4)^3\\H^3\end{matrix}\right\}\begin{matrix}N\\O^3\end{matrix};\ \text{type}\left.\begin{matrix}H^3N\\3(H^2O)\end{matrix}\right\}$$

IH, is capable, under certain circumstances, of ex-
gen successively for a metal, or for a compound radicle,
to a numerous class of compounds, all deriving from
arliest discovered of these compounds were some of
ogen was thus replaced, *e.g.* NHHK, which was re-
midogen) with potassium, NH^2K, and called *amide* of
ide, CNK. In process of time, compounds came to be
pe NHHH, in which 2 or 3 atoms of hydrogen were
adicles, to which the name amide in its original sense
gen, NH^2, was plainly inapplicable; accordingly these
other names, *imides*, *nitriles*, &c., the introduction of
onfusion, since they in no way indicate the common
s.

een made, chiefly by Gerhardt, to remedy this confu-
ous class of compounds a rational constitution which
on derivation, and a nomenclature by which this con-
These attempts have been attended with considerable
dopted in this article is based upon that given by
. Ch. Phys. [3] xlvi.), certain modifications being
s seems thereby to be attained.
is capable of being replaced either by acid- or by base-
e first obvious division of the compounds thus formed
the radicle which has been substituted for hydrogen.
hree great divisions:
ore atoms of hydrogen are replaced by an *acid*-radicle.
nfine the name of **amides**. In the case of each in-
generic name is preceded by a prefix, which indicates
adicles contained in the compound, *e.g.* acetamide
$^3O)^2H$, &c.
ore atoms of hydrogen are replaced by *base*-radicles.
For examples of the nomenclature of individuals,
$.K.H^2$, ethylamine, $N.C^2H^5.H^2$, methylethylamine,

nore atoms of hydrogen are replaced by *acid-* and
call **alkalamides**. Examples are ethylacetamide,
nide, $N.C^6H^5.(C^7H^5O)^2$.
ables us to perceive in compounds deriving from the
e seriation of properties which was first pointed out
eriving from the type oxide, OHH. As in the latter
ses) occupying the positive extreme, acids the negative
is filled up by salts, containing at once an acid- and
case, we have amines at the positive extreme, amides
between the two extremes.
n is furnished by the fact that amides, amines, and
2, or 3 molecules of ammonia, according as they con-
atomic radicles. Hence we have a further division of

riving from 1 mol. ammonia NHHH.
" 2 mols. " $N^2H^2H^2H^2$.
" 3 mols. " $N^3H^3H^3H^3$.
amines and alkalamides.

H, $N^2H^2H^2H^2$, $N^3H^3H^3H^3$, one third, two thirds, or the
eplaced by acid- or base-radicles: hence arises a further
d triamides into:

ydrogen is replaced, NAHH, $N^2A''H^2H^2$, $N^3A'''H^3H^3$.
hydrogen is replaced, NA^2H, $N^2(A'')^2H^2$, $N^3(A''')^2H^3$.
of the hydrogen is replaced, NA^3, $N^2(A'')^3$, $N^3(A''')^3$.

amines, and (partially) to alkalamides.
general principles of classification which we adopt, we
ed consideration of amides, amines, and alkalamides.
complete list of these compounds, but merely to cite a
ustrate our classification; and to enumerate the prin-
mation and decomposition of each group is effected.

AMIDES.

I. Monamides or Amides.

1. *Primary Amides.* They represent 1 molecule of ammonia, in which 1 atom of hydrogen is replaced by a monatomic acid-radicle (of a monobasic acid):

Acetamide	$N.C^2H^3O.H^2$
Propionamide	$N.C^3H^5O.H^2$
Benzamide	$N.C^7H^5O.H^2$
Cyanamide	$N.CN.H^2$
Sulphophenylamide	$N.C^6H^5SO^2.H^2$.

They differ from the ammonium-salt of their acids in containing the element of 1 atom of water less:

$$\underset{\text{Acet. amm.}}{C^2H^3O^2(NH^4)} - H^2O = \underset{\text{Acetamide.}}{N.C^2H^3O.H^2}$$

They are formed: 1. By the action of ammonia on anhydrides (Gerhardt).

$$\underset{\text{Benzoic anhyd.}}{(C^7H^5O)^2O} + NH^3 = \underset{\text{Benzoic acid.}}{C^7H^5O.H.O} + \underset{\text{Benzamide.}}{N.C^7H^5O.H^2}$$

2. By the action of ammonia (Liebig and Wöhler), or of carbonate of ammonium (Gerhardt) on the chlorides of acid-radicles:

$$\underset{\substack{\text{Chloride of}\\\text{cyanogen.}}}{CNCl} + NH^3 = HCl + \underset{\text{Cyanamide.}}{N.CN.H^2}$$

This method is especially adapted to the formation of those amides which are insoluble or nearly so, in water.

3. By the action of ammonia on ethers:

$$\underset{\text{Acetic ether.}}{C^2H^3O.C^2H^5.O} + NH^3 = \underset{\text{Alcohol.}}{C^2H^6O} + \underset{\text{Acetamide.}}{N.C^2H^3O.H^2}$$

This method is peculiarly adapted to the formation of soluble amides. Glycerides, with ammonia, also yield an amide, and glycerin. (Berthelot.)

4. Some primary amides have special methods of formation: *e. g.* benzamide is formed by oxidising hippuric acid with peroxide of lead:

$$C^9H^9NO^3 + 3O = N.C^7H^5O.H^2 + 2CO^2 + H^2O$$

Primary amides are mostly solid and crystalline, easily fusible, neutral to test paper, volatile without decomposition. Some of them, *e. g.* acetamide, combine with acids: others *e. g.* benzamide, can exchange 1 atom of hydrogen for a metal, forming metallic salts, or alkalamides. They are generally soluble in alcohol or ether: some in water.

Reactions.—1. Boiled with acids or with alkalis (some with water), they take up H^2O and regenerate the acid and ammonia.

2. Treated with phosphoric anhydride, they lose H^2O, and yield the corresponding nitrile. The same reaction frequently takes place when they are passed in the state of vapour over caustic lime.

$$\underset{\text{Acetamide.}}{N.C^2H^3O.H^2} - H^2O = \underset{\substack{\text{Aceto-}\\\text{nitrile.}}}{N.C^2H^3}$$

3. Treated with pentachloride of phosphorus, they behave as though they were oxides, yielding oxychloride of phosphorus, and the chloride of the radicle which they may be supposed to contain, if derived from the type HHO (Gerhardt):

$$\underset{\text{Benzamide.}}{C^7H^6N.H.O} + PCl^5 = PCl^3O + HCl + \underset{\substack{\text{Chloride of}\\\text{benzamyl.}}}{C^7H^6N.Cl}$$

The chloride thus formed is readily decomposed by heat, frequently below 100° C. into hydrochloric acid and the corresponding nitrile, $C^2H^4NCl = HCl + N.C^2H^3$ (aceto-nitrile).

4. With nitrous acid they yield their corresponding acid, with evolution of nitrogen:

$$\underset{\text{Benzamide.}}{N.C^7H^5O.H^2} + NO^2H = NN + H^2O + \underset{\substack{\text{Benzoic}\\\text{acid.}}}{C^7H^6O^2}$$

2. *Secondary Amides.*—They represent 1 molecule of ammonia, in which 2 atoms of hydrogen are replaced: (*a*) by 2 monatomic acid-radicles. (*b*) by 1 diatomic acid-radicle of a (dibasic acid).

omic radicles ;

. . . . . $N.(C^2H^3O)^2.H$
le . . . . $N.C^6H^5SO^2.C^7H^5O.H$

ction of chlorides of acid-radicles on primary amides, t):

$H^5O.Cl = HCl + N.C^6H^5SO^2.C^7H^5O.H.$
loride of benzoyl. Sulphophenyl-benzamide.

ric acid on primary amides, at a high temperature

$+ HCl = NH^4Cl + N.(C^2H^3O)^2.H$
Diacetamide.

ble in ammonia. They exhibit acid properties, red- their remaining atom of hydrogen for a metal: the ve in ammonia, producing compounds which Gerhardt hich, as they contain only monatomic radicles, it is onalkalamides containing a compound ammonium:

$H^3 = N.C^6H^5SO^2.C^7H^5O.NAgH^3$ (monalkalamide).
or $N^2.C^6H^5SO^2.C^7H^5O.Ag.H^3$ (dialkalamide).

. Ch. Phys. [3] liii.), pentachloride of phosphorus acts way as on primary amides:

$Cl^5 = PCl^3O + HCl + N(C^7H^5)(C^6H^5SO^2)Cl$
Chloride of sulphophenyl-bezamidyl.

nposed by heat:

$I^5SO^2)Cl = N.C^7H^5 + C^6HSO^2.Cl$
Benzo-nitrile. Chloride of sulphophenyl.

mic radicle. These are the bodies generally called ining *imidogen*, NH. Though we reject this view of name for convenience sake.

id) . . . . . . $N.(CO)''.H$
. . . . . . $N.(C^4H^4O^2)''.H$
. . . . . . $N.(C^{10}H^{14}O^2)''.H.$

monium-salts of their acids by containing 2 atoms of

$H^4)H - 2H^2O = N.C^4H^4O^2.H$
nate of ım. Succinimide.

ly than secondary amides (*a*):
ium-salts of dibasic acids.
es:

$)^2.H^4 = N.C^4H^4O^2.H + NH^3.$
nide. Succinimide.

urent):

$^2.H.O = H^2O + N.C^{10}H^{14}O^2.H$
acid. Camphorimide.

des with ammonia:

$+ NH^3 = H^2O + N.C^4H^4O^2.H$
Succinimide.

properties, and readily exchange their basic hydrogen s identical with cyanic acid.

ids or alkalis, they take up $2H^2O$ and regenerate the

$+ 2H^2O = C^4H^4O^4.H^2 + NH^3.$

it this reaction.

a, they form the ammonium-salt of the corresponding

$+ NH^4.HO = N.C^4H^4O^2.H^2.NH^4.O$
Succinamate of amm.

3. *Tertiary Amides.*—They represent 1 molecule of ammonia, in which all the hydrogen is replaced: (*a*) by 3 monatomic, (*b*) by 1 diatomic and 1 monatomic, (*c*) by 1 triatomic, acid-radicle:

a. H^3 *are replaced by* 3 *monatomic radicles:*

Sulphophenyl-benzoyl-acetamide . . $N.C^6H^5SO^2.C^7H^5O.C^2H^3O$.

b. H^3 *are replaced by* 1 *diatomic and* 1 *monatomic radicle:*

Sulphophenyl-succinamide . . . $N.C^6H^5SO^2.(C^4H^4O^2)''$.

They are formed by the action of chlorides of acid-radicles on the metallic salts of secondary amides (tertiary alkalamides):

$$N.C^6H^5SO^2.C^7H^5O.Ag + C^2H^3O.Cl = AgCl + N.C^6H^5SO^2.C^7H^5O.C^2H^3O$$
$$N.C^4H^4O^2.Ag + C^6H^5SO^2.Cl = AgCl + N.C^4H^4O^2.C^6H^5SO^2.$$

Their reactions are but little known. Boiled with dilute ammonia, the amides of class (*b*) give the ammonium-salt of the corresponding amic acid:

$$N.C^4H^4O^2.C^6H^5SO^2 + NH^4.H.O = NC^4H^4O^2.C^6H^5SO^2.H.NH^4.O.$$

Sulphophenyl-succinamide. Sulphophenyl-succinamate of ammonium.

c. H^3 *are replaced by* 1 *triatomic radicle.* To this group, by their reactions and mode of formation, the following mineral compounds belong:

$N.(PO)'''$. Gerhardt's biphosphamide (phosphorylamide) = $PO^4(NH^4)H^2 - 3H^2O$
$N.N.'''$. Free nitrogen (Nitroso-nitrile) = $NO^2.NH^4 - 2H^2O$
$N.(NO)'''$. Nitrous oxide. (Nitro-nitrile) = $NO^3.NH^4 - 2H^2O$.

II. **Diamides.**

1. *Primary Diamides.*—They represent 2 molecules of ammonia in which 2 atoms of hydrogen are replaced by 1 diatomic acid-radicle.

Sulphamide	$N^2.(SO^2)''.H^4$
Oxamide	$N^2.(C^2O^2)''.H^4$
Succinamide	$N^2.(C^4H^4O^2)''.H^4$
Carbamide (urea)	$N^2.(CO)''.H^4$

They differ from the normal ammonium-salts of their acids in containing 2 atoms of water less:

$$C^2O^4(NH^4)^2 - 2H^2O = N^2.C^2O^2.H^4$$

Oxalate of ammonium. Oxamide.

They are formed—1. By the action of ammonia on ethers:

$$C^2O^4(C^2H^5)^2 + 2NH^3 = 2C^2H^6O + N^2.C^2O^2.H^4$$

Oxalic ether. Oxamide.

2. By the action of ammonia on chlorides of acid-radicles:

$$C^4H^4O^2.Cl^2 + 2NH^3 = 2HCl + N^2.C^4H^4O^2.H^4$$

Chloride of succinyl. Succinamide.

3. By heating normal ammonium-salts of dibasic acids (Dumas).
4. By the action of ammonia on imides (Wöhler):

$$N.CO.H + NH^3 = N^2.CO.H^4$$

Carbimide. Carbamide.

By the action of ammonia on dibasic anhydrides, not primary diamides, but amic acids, are generally formed.

Many primary diamides exhibit decidedly basic properties, combining with acids and forming definite salts: *e.g.* urea, asparagine, &c.

Reactions.—1. Many of them, when heated, evolve ammonia and yield imides. 2. Boiled with acids or alkalis, they take up $2H^2O$, and regenerate the acid and ammonia:

$$N^2.C^2O^2.H^4 + 2H^2O = C^2O^4.H^2 + 2NH^3.$$

3. With nitrous acid, they regenerate their dibasic acid, with evolution of nitrogen (Piria, Malaguti):

$$N^2.C^2O^2.H^4 + 2NO^2H = 2NN + C^2O^4.H^2 + 2H^2O.$$

Oxamide. Oxalic acid.

Intermediate between primary and secondary diamides must be classed the bodies

nn. Ch. Phys. [3] xliv. 57), which he describes as
gen is replaced by an acid radicle. They are of course
drogen are replaced, 2 by a diatomic, and 1 by a mon-

etyl-urea) . . $N^2.CO.C^2H^3O.H^3$
nzoyl-urea) . . $N^2.CO.C^7H^5O.H^3$.

f chlorides of acid-radicles on urea:

$H^3O.Cl = HCl + N^2.CO.C^2H^3OH^3$
hloride of acetyl. Acetocarbamide.

1 atom of hydrogen in urea by an acid-radicle, have

le, and do not combine with acids. They are not
at into cyanuric acid and a primary amide:
$H^3) = C\,N^3O^3H^3 + 3(N.C^2H^3O.H^2)$
. Cyanuric acid. Acetamide.

erhardt's phosphamide (Ann. Ch. Phys. [3] xviii.)—
g pentachloride of phosphorus with ammonia, and boil-

$H^3 + H^2O = N^2.PO.H^3 + 5HCl$.

e of ammonium by the elements of 3 atoms of water:
$^4)^2H - 3H^2O = N^2.PO.H^3$.

They represent 2 molecules of ammonia, in which 4
y 2 diatomic acid-radicles, or by 1 diatomic and 2

rmed. (Handwb.)

They represent 2 molecules of ammonia, in which all
-radicles, one of which at least must be dibasic:

. . . $N^2.(C^4H^4O^2)^3$
enzamide . $N^2.(C^4H^4O^2).(C^6H^5SO^2)^2.(C^7H^5O)^2$.

n of chlorides of acid-radicles on the silver-salts of

$C^4H^4O^2.Cl^2 + N^2.(C^4H^4O^2)^3 + 2AgCl$.
Chloride of succinyl. Trisuccinamide.

They represent 3 molecules of ammonia, in which 3
by a triatomic acid-radicle:

. . . . $N^3.(PO)'''.H^6$.
. . . . $N^3.(C^6H^5O^4)'''.H^6$.

nonium-salts of their acids by containing $3H^2O$ less:

$H^4)^3 - 3H^2O = N^3.C^6H^5O^4.H^6$.
mm. Citramide.

action of ammonia on oxychloride of phosphorus:
$N^3.PO.H^6$. (Schiff. Ann. Ch. Pharm. ci. 300.)
tion of ammonia on citric ether:

$+ 3NH^3 = N^3.C^6H^5O^4.H^6 + 3(C^2H^5.H.O)$
Citramide. Alcohol.

hey take up $3H^2O$, and regenerate their acid and

They represent respectively 3 mols. ammonia, in which
two-thirds and the whole of the hydrogen is replaced
least must be triatomic.
groups has yet been formed.
767) regards melam, $C^6H^9N^{11}$, as a primary triamide,
admit the existence of a triatomic radicle, C^3N^3, and
basic, $C^3N^3H^3$: otherwise such compounds as ferro-
, present the anomaly of bodies deriving from a triple
only monatomic radicles.

Amines.

I. Monamines or Amines.

1. *Primary Amines.*—They represent 1 molecule of ammonia, in which 1 atom of hydrogen is replaced by a monatomic base-radicle, whether a metal or an organic radicle. They are sometimes called *amido-bases.*

Potassamine	$N.K.H^2$
Platinamine	$N.pt'.H^2$. [$pt = \frac{1}{4}Pt = 49{\cdot}3$]
Methylamine	$N.CH^3.H^2$
Ethylamine	$N.C^2H^5.H^2$
Phenylamine (Aniline) . .	$N.C^6H^5.H^2$.

Primary amines containing metals are generally obtained by the action of ammonia on the metal or its oxide. Zincamine is formed by the action of ammonia on zinc-ethyl: $Zn'C^2H^5 + NH^3 = H.C^2H^5 + NZn'H^2$.—When treated with water or acids, they are mostly decomposed, like primary amides, yielding ammonia and the hydrate of the metal.

Primary amines containing organic radicles are formed:

1. By action of ammonia on hydrobromic or hydriodic ethers (**Hofmann**):

$$\underset{\text{Iodide of methyl.}}{CH^3I} + NH^3 = HI + \underset{\text{Methylamine.}}{N.CH^3.H^2}$$

2. By action of potash on cyanic or cyanuric ethers (**Wurtz**):

$$\underset{\text{Cyanate of methyl.}}{N.CO.CH^3} + K^2H^2O^2 = \underset{\text{Carbonate of potassium.}}{CO.K^2.O^2} + \underset{\text{Methyl-amine.}}{N.CH^3.H^2}$$

3. By action of reducing agents, viz. alkaline hydrosulphates (**Zinin**), acetate of iron (**Béchamp**), on certain nitro-conjugated hydrocarbons:

$$\underset{\text{Nitrobenzene.}}{C^6H^4(NO^2)} + H^6 = 2H^2O + \underset{\text{Phenylamine.}}{N.C^6H^5.H^2}$$

Their formation is also observed in the dry distillation of several nitrogenised organic substances. (For the various modes of formation of monamines in general, primary, secondary, and tertiary, see **Kékulé**, Lehrb. d. org. Chemie, pp. 451—456.)

These primary amines are mostly liquid, boiling at a low temperature, and volatile without decomposition. They strikingly resemble ammonia in all their properties: like it they have a strong alkaline reaction; they combine directly with acids, forming salts, whence they are expelled by the fixed alkalis; they precipitate metallic solutions; with anhydrides, ethers, and chlorides of acid-radicles, they react precisely like ammonia (forming alkalamides, *q.v.*), and with hydriodic ethers they form diamides. With nitrous acid they yield nitrous ether or alcohol, with evolution of nitrogen:

$$\underset{\text{Ethylamine.}}{N.C^2H^5.H^2} + 2NO^2H = NN + 2H^2O + \underset{\text{Nitrous ether.}}{NO^2.C^2H^5}$$

$$\underset{\text{Phenylamine.}}{N.C^6H^5.H^2} + NO^2H = NN + H^2O + \underset{\text{Phenylic alcohol.}}{C^6H^6O}$$

In this group must also be included those amines whose radicle contains chlorine, bromine, iodine, or nitryl (NO^2), substituted for 1, 2, or 3 atoms of hydrogen: *e.g.* Dichlorethylamine, $N.C^2H^3Cl^2.H^2$, Chlorophenylamine, $N.C^6H^4Cl.H^2$, Dichlorphenylamine, $N.C^6H^3Cl^2.H^2$, Trichlorphenylamine, $N.C^6H^2Cl^3.H^2$, Nitrophenylamine, $N.C^6H^4.(NO^2).H^2$, &c. Their alkaline properties are less marked, the greater the number of atoms of chlorine, &c. they contain. They are formed mostly either by the direct action of chlorine, &c. on amines, or by the metamorphoses of other conjugated compounds. Nitrophenylamine is formed by the reduction of dinitrobenzene by hydrosulphate of ammonium, just as phenylamine results from the reduction of nitrobenzene by the same agent.

2. *Secondary Amines.*—They correspond to 1 molecule of ammonia, in which 2 atoms of hydrogen are replaced by two monatomic base-radicles. They are sometimes called *Imido-bases.*

Dimethylamine	$N.(CH^3)^2.H.$
Methylethylamine	$N.CH^3.C^2H^5.H.$
Ethylphenylamine	$N.C^2H^5.C^6H^5.H.$

They are formed by the action of hydriodic ethers on primary amines:

$$\underset{\text{Methylamine.}}{N.CH^3.H^2} + \underset{\text{Iodide of ethyl.}}{C^2H^5I} = HI + \underset{\text{Methylethylamine.}}{N.CH^3.C^2H.^5H}$$

y closely resemble primary amines: but they are in

dary amines two alkaloids, which have not yet been

. . . . $N.(C^5H^{10})''.H.$
. . . . $N.(C^6H^{14})''.H.$

radicles contained in these compounds are as yet
determine whether they are single diatomic radicles,
two monatomic radicles.

y represent 1 molecule of ammonia, in which all the
monatomic, (*b*) by 1 diatomic and 1 monatomic, (*c*) by

omic radicles (Nitrile-bases).

. . . . $N.K^3$
. . . $N.Hg^3$ [Hg = 100]
. . . . . $N.(CH^3)^3$
. . . . . $N.CH^3.(C^2H^5)^2.$
ne . . . . $N.CH^3.C^2H^5.C^6H^5.$

cles are formed—1. By the action of hydriodic ethers

$+ C^2H^5.I = HI + N.(CH^3)^2.C^2H^5.$
Iodide of ethyl. Dimethylethylamine.

alts of organic ammonium-bases:

$O = N.(C^2H^5)^3 + C^2H^4 + H^2O$
Triethylamine. Ethylene.

$= N.(C^2H^5)^3 + C^2H^5I.$

tassium on cyanic ether:

$H^5)^2.K^2.O^2 = N.(C^2H^5)^3 + CO.K^2.O^2$
mol. ethylate of potassium. Triethylamine. Carbonate of potassium.

that of hydrate of potassium on cyanic ethers. (See

similar in properties to primary and secondary amines:
r. They are however distinguished by one important
e exhibits in the strongest light their analogy with
erived. When acted upon by hydriodic ethers, direct
de of an organic ammonium-base being formed:

$H^5)^3 + C^2H^5.I = N(C^2H^5)^4.I$
Iodide of tetrethylium.

lline, soluble in water and alcohol: when treated with
of silver, and a hydrate of the ammonium-base:

$g^2O + H^2O = 2AgI + 2[N(C^2H^5)^4.H.O]$
Hydrate of tetrethylium.

and soluble in water: they are powerful alkalis; in
ne fixed alkalis, liberating ammonia from ammoniacal
to acid and alcohol. Precisely, therefore, as ammonia
nbines with hydriodic acid (iodide of hydrogen) HI,
NH^4I; so triethylamine (nitride of ethyl) $N(C^2H^5)^3$,
C^2H^5I, forming iodide of tetrethylium, $N(C^2H^5)^4I$.
ical compound ammonium, NH^4, playing the part of
metals, and replacing the basic hydrogen in acids to
othetical compound tetrethylium, $N(C^2H^5)$, performing
tions. The analogy could not be more complete.
omic and 1 monatomic radicle: Hofmann's ethylene-

e. H^3 are replaced by 1 triatomic radicle (Nitriles).

Acetonitrile (cyanide of methyl)	$N.(C^2H^3)'''$
Propionitrile (cyanide of ethyl)	$N.(C^3H^5)'''$
Benzonitrile (cyanide of phenyl)	$N.(C^7H^5)'''$.

They are formed—1. By the action of heat or dehydrating agents (*e.g.* phosphoric anhydride) on ammoniacal salts of monobasic acids:

$$\underset{\text{Acetate of amm.}}{C^2H^3O^2.NH^4} - 2H^2O = \underset{\text{Acetonitrile.}}{N.C^2H^3.}$$

These nitriles differ from primary amides in containing H^2O less.

2. By the action of cyanide of potassium on sulphate of ethyl and potassium (or a homologous salt), or on hydriodic ethers:

$$\underset{\substack{\text{Sulphate of ethyl}\\\text{and potassium.}}}{SO^2.(C^2H^5).K.O^2} + CN.K = \underset{\substack{\text{Sulphate of}\\\text{potassium.}}}{SO^2.K^2.O^2} + \underset{\substack{\text{Cyanide of}\\\text{ethyl or}\\\text{propio-nitrile.}}}{CN.C^2H^5}$$

This mode of formation shows that nitriles may also be regarded as cyanides ($N.C^2H^3 = CN.CH^3$), deriving from the type ClH: and it is in this light that they are usually considered. But, if we consider their formation from ammoniacal salts, and their behaviour when boiled with acids or alkalis, when they regenerate their acid and ammonia,—$NC^2H^3 + KHO + H^2O = C^2H^3O^2K + NH^3$,—we may fairly regard them as deriving from the same type with amides. And we are led to consider them as amines rather than as amides, by the fact that, in one of them at least, the radicle is clearly a basic one; in propio-nitrile, $N.C^3H^5$, the radicle is *glyceryl*, the triatomic radicle of the triatomic alcohol, glycerin, $C^3H^5.H^3.O^3$. Moreover, that they resemble amines in the property of combining with acids, is shown by the compounds which Gerhardt obtained by the action of pentachloride of phosphorus on primary amides (*q. v.*) $C^7H^6NCl = N.C^7H^5 + HCl$.

In order to show the connection between nitriles and the acids from whose ammonium-salts they are formed, *e.g.* of acetonitrile $N.C^2H^3$, with acetic acid, $C^2H^4O^2$, and acetic compounds generally, it may be observed that acetic compounds may be represented as containing the triatomic radicle C^2H^3. Thus acetic acid may be written $(C^2H^3)'''.H.O^2$, deriving from the double type H^4O^2: acetamide, $N.H.C^2H^3.H.O$, deriving from the double type $NH^3 + H^2O$: chloride of acetyl, $Cl.C^2H^3.O$, deriving from the double type $ClH + H^2O$: acediamine, $N^2.C^2H^3.H^3$, deriving from the double type N^2H^6.

We have already seen that, when an amine which contains any replaceable hydrogen (primary or secondary amines), is treated with the iodide of an organic basic radicle, the result is the replacement of the basic hydrogen by the organic radicle: but that when tertiary amines, in which all the basic hydrogen is already replaced, are similarly treated, the result is a direct combination of the iodide with the amine. Hence we are enabled to class as tertiary amines many natural organic alkalis, which combine directly with organic iodides; of whose constitution, as they cannot be formed artificially, we should otherwise be ignorant. Among these are the following homologous alkalis, obtained by the dry distillation of animal matter:

Pyridine	$N.C^5H^5$
Picoline	$N.C^6H^7$
Lutidine	$N.C^7H^9$
Collidine	$N.C^8H^{11}$
Parvoline	$N.C^9H^{13}$.

Also the numerous vegetable alkalis or alkaloids (quinine, strychnine, morphine, &c.), which have been extracted from plants. The majority of these latter compounds contain oxygen-radicles: as many of them contain 2 atoms of nitrogen, it is possible that they must be regarded as diamines. How many radicles they may contain, we have as yet no means of determining.

II. **Diamines.**

1. *Primary Diamines.* } They represent 2 molecules of ammonia, in which
2. *Secondary Diamines.* } 2 and 4 atoms of hydrogen are replaced by 1 and 2 diatomic base-radicles. The only representatives of these groups are the compounds lately obtained by Hofmann, by the action of bromide of ethylene on ammonia; they contain the diatomic radicle ethylene, C^2H^4:

Ethylenamine	$N^2.(\overset{''}{C^2H^4}).H^4$
Diethylenamine	$N^2.(\overset{''}{C^2H^4})^2.H^2$.

$$+ N^2H^6 = 2HBr + \underset{\text{Ethylenamine.}}{N^2.\overset{\prime\prime}{C}{}^2H^4.H^4}$$

.

$$+ N^2H^6 = 4HBr + \underset{\text{Di-ethylenamine.}}{N^2.(\overset{\prime\prime}{C}{}^2H^4)^2.H^2}$$

condary and tertiary diamines, is Hofmann's diphenyl-
.H, obtained by the action of chloroform on phenylamine;
$N^2.(C^6H^5)^2.CH.H + 3HCl$.
hey represent 2 mols. ammonia, in which all the hydrogen
c, (*b*) by 2 diatomic, and 2 monatomic base-radicles.

triethylenamine, $N^2.(\overset{\prime\prime}{C}{}^2H^4)^3$, by the reaction:

$$^2 + N^2H^6 = 6NHBr + N^2.(C^2H^4)^3.$$

the compounds known as *hydramides:*

drobenzamide) . . . . $N^2.(\overset{\prime\prime}{C}{}^7H^6)^3$

. . . . $N^2.(\overset{\prime\prime}{C}{}^7H^6O)^3$.

action of ammonia on certain aldehydes:

$$) + N^2H^6 = 3H^2O + \underset{\text{Benzhydramide.}}{N^2.(C^7H^6)^3}$$

l-

luble in water, soluble in alcohol, not volatile without
omposed by hydrosulphuric acid, yielding sulph-aldehydes

$$H^6)^3 + 3H^2S = N^2H^6 + 3C^7H^6S.$$

he constitution of hydrobenzamide is confirmed by its
, $C^7H^6Cl^2$, and ammonia (Engelhardt), by the manner
s upon it (Borodine), and by the existence of a number
lorobenzol, which may be regarded as the methylate,
enzoate, &c. of the diatomic radicle C^7H^6.
diethylene-diphenylamine, $N^2.(C^2H^4)^2(C^6H^5)^2$, by the action
enylamine:

$$2(N.C^6H^5.H^2) = 4HCl + N^2.(C^2H^4)^2.(C^6H^5)^2.$$

be classed cyanogen, or oxalo-nitrile, N^2C^2, which bears
oxalate of ammonium that acetonitrile does to acetate of

$$^2O^4.(NH^4)^2 - 4H^2O = N^2C^2.$$
$$^2H^3O^2.NH^4 - 2H^2O = N.C^2H^3;$$

resent 3 molecules of ammonia, in which 3, 6, or 9 atoms
n are replaced by 1, 2, or 3 triatomic basic radicles.

is Frankland and Kolbe's *Cyanethine*, $C^9H^{15}N^3$, which,

ld be regarded as triglycerylamine, $N^3.(\overset{\prime\prime\prime}{C}{}^3H^5)^3$, a tertiary

amines.—We know but little of any complex ammonia-
than the triamines; nevertheless it appears that under
five, or even a greater number of atoms of ammonia are
complex molecule.
d tetramines with which we are acquainted are *glycosine*,
tion of ammonia on glyoxal, which may be regarded as

namine, $N^4.C^6H^{12}$, formed by the action of ammonia on

be written $N^4(C^2\overset{\prime\prime\prime}{H}{}^4)^3$ (Buttlerow, Bullet. de la Soc. Chim.
also some natural bases containing 4 at. nitrogen, *e.g.*
bromine, $C^7H^8N^4O^2$, but we know nothing of the radicles

Pentamines appear to be produced by the action of ammonia on certain metallic oxides. Some of the ammoniacal compounds of cobalt appear to be of this character; but further investigation is necessary to give accurate ideas of their constitution.

PHOSPHINES, ARSINES, STIBINES.—In connection with the basic derivatives of ammonium, we must also mention a class of bodies derived from phosphoretted hydrogen, PH^3, arsenetted hydrogen, AsH^3, and antimonetted hydrogen, SbH^3, by the substitution of alcohol-radicles for the hydrogen. All the compounds thus formed, are basic, like the alcoholic derivatives of ammonia, and form salts of exactly analogous character. Up to the present time, however, the only phosphines, arsines, and stibines, that have been obtained are those in which the whole of the hydrogen in the type is replaced by an equivalent quantity of an alcohol-radicle, *e. g.*:

Triethylphosphine	$P(C^2H^5)^3$
Trimethystibine	$Sb(CH^3)^3$

These bases have not yet been obtained by direct substitution from the hydrides of phosphorus, arsenic and antimony; but they are produced, either by submitting a metallic compound of phosphorus, arsenic, or antimony to the action of the iodides, bromides or chlorides of the alcohol radicles, *e. g.*:

$$\underset{\substack{\text{Trisodic}\\\text{arsenide.}}}{Na^3As} + \underset{\substack{\text{Iodide of}\\\text{ethyl.}}}{3C^2H^5I} = 3NaI + \underset{\substack{\text{Triethyl-}\\\text{arsine.}}}{As(C^2H^5)^3}$$

or, better in most cases, by treating the metallic compounds of the alcohol-radicles with the iodides, bromides, and chlorides of phosphorus, arsenic and antimony; thus,

$$\underset{\text{Zinc-methyl.}}{3CH^3Zn} + PCl^3 = 3ZnCl + \underset{\substack{\text{Trimethyl-}\\\text{phosphine.}}}{P(CH^3)^3}$$

These compounds, when treated with the bromides or iodides of the alcohol-radicles, behave exactly like the corresponding nitrogen-bases, producing the bromides or iodides of bases containing 4 at. of the alcohol-radicle and belonging to the ammonium type: *e. g.*:

$$\underset{\substack{\text{Triethyl-}\\\text{phosphine.}}}{P(C^2H^5)^3} + \underset{\substack{\text{Iodide of}\\\text{ethyl.}}}{C^2H^5I} = \underset{\substack{\text{Iodide of}\\\text{ethylphos-}\\\text{nium.}}}{P(C^2H^5)^4I}$$

$$\underset{\substack{\text{Trimethyl-}\\\text{phosphine.}}}{P(CH^3)^3} + C^2H^5I = \underset{\substack{\text{Iodide of trimethyl-}\\\text{ethyl-phosphonium.}}}{P(CH^3)^3(C^2H^5)I.}$$

The phosphines treated with diatomic bromides (dibromide of ethylene, for example), yield, among other products, the monobromide of a phosphonium-molecule, in which the fourth atom of hydrogen is replaced by a brominated alcohol-radicle; thus triethylphosphine, treated with dibromide of ethylene, yields the *monobromide of bromethyl-triethyl-phosphonium:*

$$P(C^2H^5)^3 + C^2H^4Br^2 = P[(C^2H^4Br)'.(C^2H^5)^3]Br.$$

(See AMMONIUM-BASES.)

ALKALAMIDES.

I. **Monalkalamides** or **Alkalamides.**

1. *Secondary Alkalamides.*—They represent 1 mol. ammonia in which 2 atoms of hydrogen are replaced, one by an acid, the other by a base radicle.

Mercurobenzamide	$N.Hg'.C^7H^5O.H.$
Argentosulphophenylamide	$N.Ag.C^6H^5SO^2.H.$
Ethylformamide	$N.C^2H^5.CHO.H.$
Ethylacetamide	$N.C^2H^5.C^2H^3O.H.$
Phenylbenzamide (benzanilide)	$N.C^6H^5.C^7H^5O.H.$
Ethylcyanamide	$N.C^2H^5.CN.H.$

Those which contain metals are formed by the action of primary amides on metallic oxides; they are decomposed by most acids, which remove their metal. Those containing silver are readily attacked by chlorides of acid-radicles, yielding secondary amides and chloride of silver:

$$\underset{\substack{\text{Argentosulphophe-}\\\text{nylamide.}}}{N.Ag.C^6HSO^2.H} + \underset{\substack{\text{Chloride of}\\\text{benzoyl.}}}{C^7H^5O.Cl} = AgCl + \underset{\text{Sulphophenylbenzamide.}}{N.C^6H^5SO^2.C^7H^5O.H.}$$

base-radicles, are formed by the same reactions as primary
ng substituted for ammonia:
mines on monobasic anhydrides (**Gerhardt**):

$$C^7H^5O)^2O = C^7H^5O.H.O + N.C^6H^5.C^7H^5O.H.$$

enzoic an- ydride. Benzoic acid. Phenylbenzamide.

mines on chlorides of acid-radicles (**Gerhardt**):

$$+ C^2H^3O.Cl = HCl + N.CH^3.C^2H^3O.H$$

Chloride of acetyl. Methylacetamide.

mines on ethers:

$$H^3O.C^2H^5.O = C^2H^5.H.O + N.C^2H^5.C^2H^3O.H.$$

cetic ether. Alcohol. Ethylacetamide.

acids on cyanic ethers (**Wurtz**):

$$N.C^2H^5.CO = CO.O + N.C^2H^5.CHO.H.$$

Cyanate of ethyl. Carbonic anhyd. Ethyl-formamide.

generally do not combine with acids; boiled with acids
, and regenerate their acid and primary amine:

$$).H + H^2O = N.C^6H^5.H^2 + C^2H^3O.H.O.$$

ide. Phenylamine. Acetic acid.

act as weak alkalis, forming with concentrated acids com-
d by water. By heat they are decomposed in rather a
ertiary alkalamide, and a kind of intermediate dialkala-
onatomic radicles:

$$.H) = N.(C^2H^5)^2.CN + N^2.C^2H^5.(CN)^2.H^3$$

de Diethylcyanamide. Ethyldicyandiamide.

(Ann. Ch. Phys. [3] liii. 307) secondary alkalamides are
of phosphorus in the same way as primary and secondary

$$+ PCl^5 = N(C^7H^5)'''(C^6H^5)Cl + POCl^3 + HCl.$$

Chloride of phenyl-benzamidyl.

es.—They represent 1 molecule of ammonia in which all
by 1 basic and 2 acid monatomic radicles; (*b*) by 2 basic
es; (*c*) by 1 basic monatomic, and 1 acid diatomic radicle.
ic and 2 *acid monatomic radicles:*

. . . . . . $N.C^2H^5.(C^2H^3O)^2$
e . . . . . $N.C^6H^5.(C^7H^5O)^2$

of acid-radicles on secondary alkalamides (**Gerhardt**

$$H + C^7H^5O.Cl = HCl + N.C^6H^5.(C^7H^5O)^2.$$

. Chloride of benzoyl. Phenyldibenzamide.

anhydrides on cyanic ethers (**Wurtz**):

$$N.C^2H^5.CO = CO.O + N.C^2H^5.(C^2H^3O)^2$$

Cyanate of ethyl. Ethyldiacetamide.

ombining neither with acids nor with bases.
sic and 1 *acid monatomic radicle:*

mide . . . . . $N.CH^3.C^7H^5.CN$
. . . . . . $N.(C^2H^5)^2.CN.$

s group hitherto formed, contain cyanogen as the acid-
y the action of chloride of cyanogen on secondary amines

$$.H + CN.Cl = HCl + N.C^2H^5.C^6H^5.CN.$$

ne. Ethylphenylcyanamide.

le without decomposition. Heated with acids or alkalis, they regenerate a secondary amine and cyanic acid, which latter is further decomposed into carbonic anhydride and ammonia:

$$\underset{\text{Diethyl-cyanamide.}}{N.(C^2H^5)^2.CN} + HHO = \underset{\text{Diethylamine.}}{N.(C^2H^5)^2.H} + \underset{\text{Cyanic acid.}}{CN.H.O.}$$

$$\underset{\text{Cyanic acid.}}{N.CO.H} + H^2O = NH^3 + CO.O$$

c. H^2 *are replaced by* 1 *monatomic basic, and* 1 *diatomic acid, radicle.*—As these compounds correspond to those secondary amides which are commonly called imides we will retain the same termination for them:

Phenyl-succinimide (succinanile)	$N.C^6H^5.(C^4H^4O^2)''$
Ethyl-carbimide (cyanic ether)	$N.C^2H^5.(CO)''$

With the exception of cyanic ethers, the only members of this group that have been studied are those containing phenyl as their basic radicle; they are commonly called *aniles.* They are obtained by the action of phenylamine on dibasic anhydrides or acids (probably also on the corresponding chlorides):

$$N.C^6H^5.H^2 + \underset{\text{Camphoric anhydride.}}{C^{10}H^{14}O^2.O} = H^2O + \underset{\text{Phenylcamphorimide.}}{N.C^6H^5.C^{10}H^{14}O^2}$$

$$N.C^6H^5.H^2 + \underset{\text{Camphoric acid.}}{C^{10}H^{14}O^2.H^2.O^2} = 2H^2O + N.C^6H^5.C^{10}H^{14}O^2.$$

Boiled with dilute ammonia, they form the ammonium-salt of an amic acid:

$$\underset{\text{Phenylsuccinimide.}}{N.C^6H^5.C^4H^4O^2} + NH^4.H.O = \underset{\text{Phenylsuccinamate of ammonium.}}{N.\overbrace{H.C^6H^5.C^4H^4}^{'''}\overbrace{O^2.NH^4}^{''}.O}$$

Fused with potash, they regenerate phenylamine and their acid:

$$N.C^7H^5.C^4H^4O^2 + K^2H^2O^2 = \underset{\text{Succinate of potassium.}}{C^4H^4O^2.K^2.O} + N.C^6H^5.H^2.$$

As cyanic acid may be regarded as carbimide, cyanic ethers may obviously be regarded as alkalimides. With potash they exhibit the same reaction as the foregoing alkalimides:

$$N.C^2H^5.CO + K^2H^2O^2 = CO.K^2.O^2 + N.C^2H^5.H^2.$$

By the action of water or ammonia, they form Dialkalamides (compound ureas):

$$\underset{\text{2 mol. cyanic ether.}}{N^2.(C^2H^5)^2.(CO)^2} + H^2O = CO.O + \underset{\text{Diethylcarbamide.}}{N^2.CO.(C^2H^5)^2.H^2.}$$

$$N.C^2H^5.CO + NH^3 = \underset{\text{Ethylcarbamide.}}{N^2.CO.C^2H^5.H^3.}$$

II. **Dialkalamides.**

There are no primary dialkalamides: but there exists a class of compounds occupying an intermediate place between primary and secondary dialkalamides. They represent 2 mols. of ammonia, in which 3 atoms of hydrogen are replaced, 2 by a diatomic acid-radicle, and 1 by a monatomic base-radicle. With the exception of phenyl-oxamide, $N^2.C^6H^5.C^2O^2.H^3$, the only members of this class are the *compound ureas*, representing urea or carbamide in which 1 H is replaced by a base-radicle:

Ethyl-carbamide (ethyl-urea)	$N^2.(CO)''.C^2H^5.H^3$
Phenyl-carbamide (phenyl-urea)	$N^2.(CO)''.C^6H^5.H^3.$

They are formed by the action of a primary amine on cyanic acid, or of ammonia on cyanic ethers:

$$\begin{aligned} N.C^2H^5.H^2 &+ N.CO.H &&= N^2.CO.C^2H^5.H^3 \\ NH^3 &+ N.CO.C^2H^5 &&= N^2.CO.C^2H^5.H^3 \end{aligned}$$

They are decomposed by potash, yielding carbonate, a primary amine and ammonia:

$$N^2.CO.C^6H^5.H^3 + H^2.K^2.O^2 = CO.K^2.O^2 + N.C^6H^5.H^2 + NH^3.$$

2. *Secondary Dialkalamides.*—They represent 2 molecules of ammonia in which 4 atoms of hydrogen are replaced by 2 monatomic base-radicles and 1 diatomic acid radicle:

Dimethyloxamide	$N^2.(CH^3)^2.(C^2O^2)''.H^2$
Diphenylsuccinamide	$N^2.(C^6H^5)^2.(C^4H^4O^2)''.H^2$
Diethylcarbamide (diethyl-urea)	$N^2.(C^2H^5)^2.(CO)''.H^2$

salts of organic alkalis:

$H^3.H^3)^2 - 2H^2O = N^2.(CH^3)^2.C^2O^2.H^2$

methy- Dimethyloxamide.

mines on ethers of dibasic acids:

$.(CH^3)^2.H^4 = (C^2H^5)^2.H^2.O^2 + N^2.(CH^3)^2.C^2O^2.H^2.$

mol. methyl-amine. 2 mol. alcohol. Dimethyloxamide.

nines on chlorides of acid-radicles:

$H^2 + CO.Cl^2 = 2HCl + N^2.(C^6H^5)^2.CO.H^2.$

e. Chloride of carbonyl. Diphenylcarbamide.

l-carbamides) belonging to this group are also formed by
ethers:

$) + H^2O = CO.O + N^2.(C^2H^5)^2.CO.H^2.$

Diethylcarbamide.

lamides are decomposed by potash, yielding a primary
sium-salt of their acid:

$^2 + H^2K^2O^2 = N^2.(C^2H^5)^2.H^4 + C^2O^2.K^2.O^2$

2 mols. ethyl-amine. Oxalate potass.

ne, $C^{13}H^{11}N^3$, and a compound, $C^{19}H^{17}N^3$, which he has ob-
ride of carbon on phenylamine, as cyan-diphenyldiamide,
iphenyldiamide, $N^2.CN.(C^6H^5)^3.H^2$, respectively,—*i. e.* as
monatomic radicles. Considering the reaction by which
npounds is formed, it may perhaps be preferable to regard
les of ammonia, in which a portion of the hydrogen is
dicle, $C^{\prime\prime\prime\prime}$ viz. as $N^3.C.(C^6H^5)^3.H^2$.
llowing compounds, intermediate between secondary and

. . . . . $N^2.(C^6H^5)^2.(C^6H^5O^4)^{\prime\prime\prime}.H$
. . . . . $N^2.(C^6H^5)^2.(C^6H^3O^2)^{\prime\prime\prime}.H.$

nacid phenylium-salts of tribasic acids, less the elements

$.H^3)^2H - 3H^2O = N^2.(C^6H^5)^2.C^6H^5O^4.H.$

ides.—They represent 2 molecules of ammonia in which
by base- and acid-radicles, one of which at least must be
represented by compound-ureas, in which all the hydro-
radicles,—*e.g.* Tetrethylcarbamide or tetrethyl-urea,
f's sulphocyanide of ethylene (ethylene-disulphocarbamide)
boiling chloride of ethylene with an alcoholic solution of
(Proc. Roy. Soc. viii. 188), and by Hofmann's diphenyl-
$)(C^6H^5)^{2\prime\prime}$, obtained by the action of dilute hydrochloric

$l + 3H^2O = 3NH^4Cl + N^2.CO.C^2O^2.(C^6H^5)^2$

tained by the action of secondary amines on chlorides of
dibasic acids:

$C^4H^4O^2.Cl^2 = 2HCl + N^2.(CH^3)^4.C^4H^4O^2.$

Tetramethylsuccinamide.

$O^2.(C^2H^5)^2.O^2 = 2(C^2H^5.H.O) + N^2.(C^2H^5)^4.C^4H^2O^2$

cinate of ethyl. Tetrethylsuccinamide.

amides.—They correspond to 3 molecules of ammonia, in
re replaced by 1 triatomic acid-radicle and 3 monatomic
Pebal's triphenylcitramide, $N^3.(C^6H^5)^3.(C^6H^5O^4)^{\prime\prime\prime}.H^3$, ob-
acid on phenylamine:

$(N.C^6H^5.H^2) = N^3.(C^6H^5)^3.C^6H^5O^4.H^3 + 3H^2O$

al citrate of phenylium, less the elements of 3 atoms of
nylphosphamide, $N^3.(C^6H^5)^3.PO.H^3$, and trinaphtylphos-

phamide, $N^3.(C^{10}H^7)^3.PO.H^3$, obtained by the action of phenylamine and naphtylamine respectively on oxychloride of phosphorus (Ann. Ch. Pharm. ci. 300):

$$POCl^3 + 3(N.C^6H^5.H^2) = N^3.(C^6H^5)^3.PO.H^3. + 3HCl.$$

2. *Tertiary Trialkalamides.*—The cyanuric ethers may be placed in this division, *e. g.* cyanurate of ethyl, $N^3.(\overset{''}{C}O)^3.(C^2H^5)^3$.—F. T. C.

AMMELIDE and **AMMELINE.** See CYANURAMIC ACIDS.

AMMIOLITE. A red earthy mass from Chile, containing 36·5 antimony, 14·8 tellurium, 12·2 copper, 22·2 mercury, and 2·5 quartz, besides oxygen; probably a mixture. (*Rammelsberg's Mineralchemie*, p. 426.)

AMMONIA. NH^3. (Synonymes, *Volatile alkali*, *Alkaline air*, *Ammoniacal gas*, *Ammoniaque*, *Ammoniak.*)

History. — The earliest mention of aqueous ammonia, which was known long before the gas itself, is made by Raymond Lully, in the thirteenth century: he prepared it from urine, and called it *Mercurius vel spiritus animalis.* Basil Valentine, in the fifteenth century, first prepared it from sal-ammoniac: he still retained the name *spiritus urinæ.* It was Bergman (1782) who first designated it by the name *ammonia.* Ammoniacal gas was discovered by Priestley, who describes it in 1774 by the name of *alkaline air*; he also observed its decomposition by the electric spark. Scheele, in 1777, ascertained that it contained nitrogen, regarding it as a compound of nitrogen and phlogiston. Its true composition was first ascertained by Berthollet (1785); and it was finally analysed with still greater exactness, by his son Am. Berthollet in 1808.

Natural Sources. — Ammonia exists in the air as carbonate of ammonium: in rain-water, especially in that of thunder-showers, as nitrate. In sea-water, and in many mineral springs. In most kinds of clay and soils: in sesquioxide of iron, and in the majority of iron-ores. Sal-ammoniac and ammonium-alum are found as minerals, the former chiefly in volcanic regions, and in some specimens of rock-salt. As ammoniacal-salts, in animal fluids and excrements (especially in urine), and in the juices of many plants.

Formation. — Ammonia cannot be formed by the direct combination of its elements in the free state. When 1 vol. nitrogen and 3 vols. hydrogen are passed through a red-hot tube, no ammonia is formed, not even if spongy platinum be present. But it is formed with great readiness by the combination of its elements, when one or both of them is in the *nascent* state: *i. e.* at the moment of its liberation from another compound: and in this manner ammonia may be formed from many substances, organic and inorganic.

1. *From inorganic substances.* — On igniting a mixture of oxygen, nitrogen, and excess of hydrogen, nitrate of ammonium is formed. (Th. Saussure.)

a. *Formation from nascent hydrogen and free nitrogen.* — Water containing atmospheric air yields nitric acid at the positive pole, and ammonia at the negative pole of a voltaic battery (Sir H. Davy). Moistened iron-filings, in contact with atmospheric air or nitrogen at the ordinary temperature, induce the formation of ammonia (Chevallier, Berzelius). (Will states that no ammonia is thus formed.) This reaction accounts for the existence of ammonia in rust of iron, and iron ores generally. When liver of sulphur is fused with an equal weight of iron-filings, and water dropped on the hot mass, ammonia is evolved (Hollunder). When certain metals which combine readily with oxygen (potassium, arsenic, lead, iron, &c.) are heated with the hydrates of potassium, sodium, barium, or calcium, in contact with air, ammonia is formed. Faraday states that this formation of ammonia takes place even in an atmosphere of hydrogen: a fact explained by Bischof as arising from the difficulty of obtaining hydrogen free from atmospheric air. Reiset also points out that the hydrogen will contain nitric oxide, if the sulphuric acid employed for its generation contains nitric acid or nitric oxide.

b. *Formation from nascent nitrogen and free hydrogen.*— A mixture of 2 vols. nitric oxide and 5 vols. hydrogen passed over gently heated spongy platinum, yields ammonia and water (Hare; Ville, Ann. Ch. Phys. [3] xlvi.) The same gases when passed through a red-hot tube, only yield ammonia when some porous substance is present; pumice-stone, or ferric oxide acts most energetically (Reiset). Nitrous oxide and hydrogen in excess yield ammonia when in contact with hot spongy platinum or platinum-black. Hydrogen saturated with nitric acid vapour acts in a similar manner.

c. *Formation from nascent hydrogen and nascent nitrogen.* — Moist nitric oxide passed over heated iron-filings yields ammonia. A mixture of nitric oxide and hydrosulphuric acid, passed over heated soda-lime, yields ammonia (Ville). Certain metals which decompose water at a high temperature (iron, zinc, &c.), when treated with dilute nitric acid, or the aqueous solutions of certain nitrates, yield ammonia. Ammonia is formed when nitric acid is added to zinc and sulphuric acid in a hydrogen

nposition of chloride, iodide, and phosphide of nitrogen,
o the class, amides, by water. When a mixture of baryta
eated in contact with air, cyanide of barium is formed, a
osed by steam at 300° C. into carbonate of barium and
Sourdeval have lately proposed to employ this process for
on the large scale. (Rép. Chim. App. ii. 170.)
s. — Many *non-nitrogenous* organic bodies form ammonia
r and water: *e.g.* in the process of putrefaction. Sugar,
ammonia when heated with alkaline or alkaline-earthy
r. Oxygen-compounds of nitrogen, heated with organic
oxide with alcohol-vapour, nitric acid with gum, form
l organic compounds yield ammonia, either free or com-
refaction or of dry distillation: it is from this source that
re is chiefly derived.
l-ammoniac is mixed with twice its weight of slaked lime,
yer of coarsely powdered quick lime, about equal in weight
d the whole heated gradually in a flask or retort: for the
a large scale, iron vessels are used. The gas is passed
, in which aqueous vapour is condensed, and any solid
d over are arrested; it is then dried by passing over solid
ter, a mixture of the anhydrous oxides of potassium and
nitrate of potassium with finely divided copper reduced
Stas), (chloride of calcium absorbs the gas)—and collected
pure, it should be entirely absorbed by water. In order
ia, Vogel recommends saturating a concentrated aqueous
lid chloride of calcium, heating gently, and passing the

as, of a pungent smell, and strong alkaline taste. Its
0·5893; (H. Davy) 0·5901; (Thomson) 0·5931; (Biot
at 0° C. and 760mm. barometric pressure weighs 0·7752
s specific heat (water = 1) is 0·508 (Regnault). Its
1·309 (Dulong).
combustion or respiration: animals die when immersed
ole: when issuing in a thin stream into atmospheric air,
s with a pale flame. It colours turmeric paper brown,
e colours disappear on exposure to the air.
d and pressure, and obtained both in the liquid and solid
uid ammonia as follows: Ammonio-chloride of silver is
glass tube, closed at one end, which is then bent at an
ng in the longer limb. The shorter limb is then sealed
e chloride gradually heated: it fuses at 38° C., and be-
s off all its ammonia, which condenses to a liquid by its
of the tube. As the chloride of silver cools, the liquid
is reabsorbed by the chloride. Guyton de Morveau and
onia without pressure by a mixture of chloride of calcium
C., the latter at −40°. Liquid ammonia is a colourless, very
ht more powerfully than water; specific gravity 0·76:
rometic pressure, −33·7° C. (Bunsen.) Its tension at
eres: at 0° C. = 4·44 atm.: at 10·8° C. = 6 atm.: at
8·31° C. = 10 atm.
d ammonia by exposing the dry gas to a pressure of 20
—75° C., produced by solid carbonic anhydride and ether.
ystalline body, which melts at −75° C., and has a higher
mmonia.
monia is decomposed by a succession of electric sparks:
e volume of the original gas, and consists of 1 vol. nitrogen
by being passed through a red-hot porcelain tube contain-
d-, silver-, or platinum-wire acts similarly, but less ener-
duced in the gold and platinum-wire: the copper and iron
d sometimes increased in weight, owing to the formation
ia mixed with not less than 1, nor more than 6 vols.
electric spark: the products, if the oxygen be in excess,
monium; if the ammonia be in excess, water, nitrogen,
monia, in contact with finely divided copper or platinum,
ir, is converted into nitrite of ammonium, both its con-
on (Handwb.)—Ammonia is decomposed by several of the
ne and nitrogen. Dry ammonia mixed with dry *hypo-*

chlorous anhydride explodes violently at the ordinary temperature, with separation of chlorine. Aqueous ammonia added gradually to aqueous *hypochlorous acid*, the mixture being kept cool, yields nitrogen, and chloride of nitrogen. Ammonia mixed with proper proportions of *nitrous or nitric oxide*, explodes by the electric spark, yielding water and nitrogen. Ammonia is violently decomposed at the ordinary temperature by *peroxide of nitrogen*, whether liquid or gaseous, with evolution of nitric oxide and nitrogen (Dulong).—In contact with *chlorine* in the cold, ammonia burns with a red and white flame, forming chloride of ammonium and free nitrogen ($4NH^3 + Cl^3 = 3NH^4Cl + N$); when chlorine is passed into strong aqueous ammonia or a solution of an ammoniacal-salt, chloride of nitrogen is also formed. — *Iodine* does not decompose dry ammonia: in presence of water, iodide of ammonium and an iodine-derivative of ammonia are formed.—With *bromine*, ammonia yields bromide of ammonium and free nitrogen.—Passed with vapour of *phosphorus* through a red-hot tube, ammonia yields phosphide of hydrogen and free nitrogen.—Passed over red-hot *charcoal*, ammonia yields cyanide of ammonium and free hydrogen.—With *bisulphide of carbon*, ammonia gives hydrosulphuric and sulphocyanic acids ($NH^3 + CS^2 = H^2S + CSH$).—When *potassium* or *sodium* is heated in dry ammonia, hydrogen is evolved, its place being supplied by the metal, and nitride of potassium and hydrogen (potassamine), NKH^2, is formed.—In contact with zinc-ethyl, ammonia gives zinc-amine $NZnH^2$ and hydride of ethyl, C^2H^6. Many *metallic oxides* decompose ammonia with the aid of heat: the products are sometimes water, nitrogen, reduced metal, and more or less of an oxygen-compound of nitrogen; sometimes, water and a metallic nitride.—Ammonia reacts with anhydrous acids, chlorides of acid-radicles, and many compound ethers, giving *amic acids*, or *amides*. In like manner, it gives with many derivatives of the alcohols, *amic bases* or *amines*. (See AMIC ACIDS, AMIC BASES, AMIDES, AMINES.)

We have seen that ammonia is decomposed by certain metals and metallic oxides, hydrogen being liberated, and compounds formed representing ammonia in which a part or the whole of the hydrogen is replaced by a metal. There are certain organic compounds (*e. g.* monobasic anhydrides, compound ethers, &c.) which are capable of decomposing ammonia in a similar manner, with formation of compounds representing ammonia in which the hydrogen is wholly or partially replaced by an organic radicle, acid or basic. The numerous and interesting class of compounds which are thus formed from ammonia by the partial or total replacement of its hydrogen by other radicles, organic or inorganic, acid or basic, is known by the generic name of *amides*: under which name they are fully described.

Combinations. — 1. *With Water* (*Solution of ammonia*, *Aqueous ammonia*, or simply *Ammonia*, *Spirits of hartshorn*, *Salmiakgeist*, *Liquor ammonii*).

Both water and ice absorb ammonia with great avidity, with considerable evolution of heat, and with great expansion. Davy found that 1 vol. water at 10° C. and 29·8 inches barometric pressure absorbs 670 vols. ammonia, or nearly half its weight: the specific gravity of this solution is 0·875. According to Dalton, water at a lower temperature absorbs even more ammonia, and the specific gravity of the solution is 0·85. According to Osann, 100 pts. water at 24° C. absorb 8·41 pts. at 55° C. 5·96 pts. ammonia. 1 vol. water by absorbing 505 vols. ammonia, forms a solution occupying 1·5 vols., and having specific gravity 0·9: this, when mixed with an equal bulk of water, yields a liquid of specific gravity 0·9455: whence it appears that aqueous ammonia expands on dilution. (Ure.)

Preparation. — 1 part of sal-ammoniac in lumps is introduced into a glass flask, with 1¼ parts slaked lime, and from 1 to 1½ parts water: and the flask is connected by bent tubes with three Woulfe's bottles. The first bottle, which is intended to arrest any solid particles that may be carried over mechanically, and any empyreumatic oil contained in the sal-ammoniac, as well as to condense aqueous vapour, contains a small quantity of water (Mohr prefers milk of lime). The second bottle contains the water to be saturated with ammonia: it should contain a quantity of water about equal in weight to the sal-ammoniac employed, and should not be more than three parts full, to allow for the expansion. These two bottles should be placed in cold water, and each provided with a safety tube. The third bottle contains a little water, to retain any ammonia that may pass through the second bottle. The flask is then heated in a sand-bath, care being taken that its contents do not boil over: and the operation continued till about half the water in the flask has distilled over into the first bottle. The first bottle then contains a weak and impure solution of ammonia: the second a pure and strong solution (if a perfectly saturated solution be required, the quantity of water in this bottle should not exceed ⅔ the weight of the sal-ammoniac employed): the solution in the third bottle is weak, but pure.

The proportions of lime and water to be added to the sal-ammoniac in order to produce the largest yield of ammonia have been variously stated: those given above are

According to the equation, $CaHO + NH^4Cl = NH^3 +$ slaked lime should be to that of sal-ammoniac as former to 100 parts of the latter. But in practice it is loy a larger proportion of lime; for not only is the lime it also it is impossible to bring the whole of it into such c, as would ensure the completeness of their reaction. to ensure the gradual solution of the sal-ammoniac, and e contact with the lime. There are also other disad-ence of water. If the lime and sal-ammoniac are mixed quantity of ammonia is lost before the mixture is intro-heated mass expands on cooling so as invariably to veniences are avoided by first placing the sal-ammoniac en covering it with the powdered lime: but in this case to volatilise the sal-ammoniac, which is liable to stop se a dangerous explosion. Moreover a larger quantity r with the ammonia: and the chloride of calcium formed a portion of the ammonia, which is consequently lost. on of too much water diminishes the product of am-ion in other ways.

us ammonia on a large scale, the gas is generated in arthenware vessels are generally found not to answer, structure.

prepared may contain the following impurities, which

Occurs when the lime employed contains much carbonate, exposed to the air. Causes turbidity when heated with

de of ammonium having been sublimed, or carried over aturated with nitric acid, gives a cloudiness with nitrate

nically. Gives a precipitate with oxalic acid: left as a

om the generating vessel. The former is detected by the blue on evaporation; the latter by hydrosulphuric acid. the sal-ammoniac. The solution has a yellow colour

onia is a colourless transparent liquid, smelling of burning, urinous taste. Its specific gravity varies from amount of ammonia it contains: its boiling-point varies , *infra.*) A perfectly saturated solution freezes between shining flexible needles: at −49° C. it solidifies to a vithout smell (**Fourcroy** and **Vauquelin**). It loses temperature below 100° C. The following tables have amount of real ammonia contained in aqueous ammonia

H. Davy.		Ure.			
ecific vity.	Percentage Ammonia.	Specific gravity.	Percentage Ammonia.	Specific gravity.	Percentage Ammonia.
8750	32·3*	0·8914	27·940	0·9363	15·900
8857	29·25	0·8937	27·633	0·9410	14·575
9000	26·00	0·8967	27·038	0·9455	13·250
9054	25·37*	0·8983	26·751	0·9510	11·925
9166	22·07	0·9000	26·500	0·9564	10·600
9255	19·54	0·9045	25·175	0·9614	9·275
9326	17·52	0·9090	23·850	0·9662	7·950
9385	15·88	0·9133	22·525	0·9716	6·625
9435	14·53	0·9177	21·200	0·9768	5·500
9476	13·46	0·9227	19·875	0·9828	3·975
9513	12·40	0·9275	18·550	0·9887	2·650
9545	11·56	0·9320	17·225	0·9945	1·325
9573	10·82				
9597	10·17				
9616	9·60				
9692	9·50*				

ed by experiment: the rest in Davy's table by calculation.

J. Otto. Determinations made at 16° C.

Specific gravity.	Percentage Ammonia.	Specific gravity.	Percentage Ammonia.	Specific gravity.	Percentage Ammonia.
0·9517	12·000	0·9607	9·625	0·9697	7·250
0·9521	11·875	0·9612	9·500	0·9702	7·125
0·9526	11·750	0·9616	9·375	0·9707	7·000
0·9531	11·625	0·9621	9·250	0·9711	6·875
0·9536	11·500	0·9626	9·125	0·9716	6·750
0·9540	11·375	0·9631	9·000	0·9721	6·625
0·9545	11·250	0·9636	8·875	0·9726	6·500
0·9550	11·125	0·9641	8·750	0·9730	6·375
0·9555	11·000	0·9645	8·625	0·9735	6·250
0·9556	10·950	0·9650	8·500	0·9740	6·125
0·9559	10·875	0·9654	8·375	0·9745	6·000
0·9564	10·750	0·9659	8·250	0·9749	5·875
0·9569	10·625	0·9664	8·125	0·9754	5·750
0·9574	10·500	0·9669	8·000	0·9759	5·625
0·9578	10·375	0·9673	7·875	0·9764	5·500
0·9583	10·250	0·9678	7·750	0·9768	5·375
0·9588	10·125	0·9683	7·625	0·9773	5·250
0·9593	10·000	0·9688	7·500	0·9778	5·125
0·9597	9·875	0·9692	7·375	0·9783	5·000
0·9602	9·750				

L. Carius. (Ann. Ch. Pharm. xcix. 164.) Determinations made at 14° C.

Specific gravity.	P. C. Amm.	Specific gravity.	P. C. Amm.	Specific gravity.	P. C. Amm.	Specific gravity.	P. C. Amm	Specific gravity.	P. C. Amm.	Specific gravity.	P. C. Amm
0·8844	36·0	0·8976	30·0	0·9133	24·0	0·9314	18·0	0·9520	12·0	0·9749	6·0
0·8848	35·8	0·8981	29·8	0·9139	23·8	0·9321	17·8	0·9527	11·8	0·9757	5·8
0·8852	35·6	0·8986	29·6	0·9145	23·6	0·9327	17·6	0·9534	11·6	0·9765	5·6
0·8856	35·4	0·8991	29·4	0·9150	23·4	0·9333	17·4	0·9542	11·4	0·9773	5·4
0·8860	35·2	0·8996	29·2	0·9156	23·2	0·9340	17·2	0·9549	11·2	0·9781	5·2
0·8864	35·0	0·9001	29·0	0·9162	23·0	0·9347	17·0	0·9556	11·0	0·9790	5·0
0·8868	34·8	0·9006	28·8	0·9168	22·8	0·9353	16·8	0·9563	10·8	0·9799	4·8
0·8872	34·6	0·9011	28·6	0·9174	22·6	0·9360	16·6	0·9571	10·6	0·9807	4·6
0·8877	34·4	0·9016	28·4	0·9180	22·4	0·9366	16·4	0·9578	10·4	0·9815	4·4
0·8881	34·2	0·9021	28·2	0·9185	22·2	0·9373	16·2	0·9586	10·2	0·9823	4·2
0·8885	34·0	0·9026	28·0	0·9191	22·0	0·9380	16·0	0·9593	10·0	0·9831	4·0
0·8889	33·8	0·9031	27·8	0·9197	21·8	0·9386	15·8	0·9601	9·8	0·9839	3·8
0·8894	33·6	0·9036	27·6	0·9203	21·6	0·9393	15·6	0·9608	9·6	0·9847	3·6
0·8898	33·4	0·9041	27·4	0·9209	21·4	0·9400	15·4	0·9616	9·4	0·9855	3·4
0·8903	33·2	0·9047	27·2	0·9215	21·2	0·9407	15·2	0·9623	9·2	0·9863	3·2
0·8907	33·0	0·9052	27·0	0·9221	21·0	0·9414	15·0	0·9631	9·0	0·9873	3·0
0·8911	32·8	0·9057	26·8	0·9227	20·8	0·9420	14·8	0·9639	8·8	0·9882	2·8
0·8916	32·6	0·9063	26·6	0·9233	20·6	0·9427	14·6	0·9647	8·6	0·9890	2·6
0·8920	32·4	0·9068	26·4	0·9239	20·4	0·9434	14·4	0·9654	8·4	0·9899	2·4
0·8925	32·2	0·9073	26·2	0·9245	20·2	0·9441	14·2	0·9662	8·2	0·9907	2·2
0·8929	32·0	0·9078	26·0	0·9251	20·0	0·9449	14·0	0·9670	8·0	0·9915	2·0
0·8934	31·8	0·9083	25·8	0·9257	19·8	0·9456	13·8	0·9677	7·8	0·9924	1·8
0·8938	31·6	0·9089	25·6	0·9264	19·6	0·9463	13·6	0·9685	7·6	0·9932	1·6
0·8943	31·4	0·9094	25·4	0·9271	19·4	0·9470	13·4	0·9693	7·4	0·9941	1·4
0·8948	31·2	0·9100	25·2	0·9277	19·2	0·9477	13·2	0·9701	7·2	0·9950	1·2
0·8953	31·0	0·9106	25·0	0·9283	19·0	0·9484	13·0	0·9709	7·0	0·9959	1·0
0·8957	30·8	0·9111	24·8	0·9289	18·8	0·9491	12·8	0·9717	6·8	0·9967	0·8
0·8962	30·6	0·9116	24·6	0·9296	18·6	0·9498	12·6	0·9725	6·6	0·9975	0·6
0·8967	30·4	0·9122	24·4	0·9302	18·4	0·9505	12·4	0·9733	6·4	0·9983	0·4
0·8971	30·2	0·9127	24·2	0·9308	18·2	0·9512	12·2	0·9741	6·2	0·9991	0·

By the aid of these tables, the strength of aqueous ammonia, like that of commercia alcohol, may be approximately ascertained by taking its specific gravity. (See als Griffin's Table given in *Ure's Dictionary of Arts, Manufactures, and Mines*, vol. i p. 132, and Chem. Soc. Qu. J. iii. 260.)

Roscoe and Dittmar (Chem. Soc. Qu. J. xii. 147), have determined the amount o ammonia-gas absorbed by water at various pressures and temperatures. The result are given in the two following tables.

Table A shows the weight of ammonia-gas in grammes G absorbed by 1 gramm of water at 0° C. and various *partial* pressures P.*

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* By partial pressure is meant the total pressure under which the absorption occurs, *minus* the tensio of aqueous vapour at 0° C.

TABLE A.

G.	P.	G.	P.	G.
0·465	0·85	0·947	1·45	1·469
0·515	0·90	0·968	1·50	1·526
0·561	0·95	1·001	1·55	1·584
0·607	1·00	1·037	1·60	1·645
0·646	1·05	1·075	1·65	1·707
0·690	1·10	1·117	1·70	1·770
0·731	1·15	1·161	1·75	1·835
0·768	1·20	1·208	1·80	1·906
0·804	1·25	1·258	1·85	1·976
0·840	1·30	1·310	1·90	2·046
0·872	1·35	1·361	1·95	2·120
0·906	1·40	1·415	2·00	2·195

ars: (1) that the quantity of ammonia absorbed by
proportional to the pressure; and (2) that for equal
out 1 metre of mercury, the corresponding increments
lly diminish, but that above this point, the amount of
e rapid ratio than the pressure.

in grammes of ammonia (column II.), absorbed by
essure of 0·76^{m}. and at various temperatures (column I).

TABLE B.

II.	I.	II.	I.	II.
0·582	32° C.	0·382	48° C.	0·244
0·554	34°	0·362	50°	0·229
0·526	36°	0·343	52°	0·214
0·499	38°	0·324	54°	0·200
0·474	40°	0·307	56°	0·186
0·449	42°	0·290		
0·426	44°	0·275		
0·403	46°	0·259		

he property of dissolving many salts which are insoluble
mic and stannic oxides, the protoxides of tin, cadmium,
nd silver. The compounds thus formed are decomposed
times with explosive violence. Many other salts are
a, *e.g.* phosphate, chloride, bromide of silver, &c.: in
be recovered unchanged by evaporating off the ammonia;
ination is effected.

moniaci alcoholicus).
ammonia in great quantity, with considerable expansion
holic solution is prepared in precisely the same way as
85—90 p. c. being substituted for water in the second
ol to the sal-ammoniac employed should be somewhat
The specific gravity of the solution of course varies
ammonia which it contains.

monia forms solid compounds with certain metallic
mercury, antimony, &c.) which are decomposed by heat,
ce. Certain metallic chlorides, bromides, and iodides
ammonia, frequently with evolution of heat. Some of
onia when exposed to the air; others, but not all, when
r without decomposition, forming solutions from which
t precipitated by dichloride of platinum: the majority
ch sometimes dissolves the original salt and separates
es the metal as hydrate. Similarly, certain crystalline
ter of crystallisation, absorb ammonia abundantly and
ompounds which are decomposed by heat or by water.
tallic cyanides, with fluoride of silicon, and other bodies.
niacal salts. (See AMMONIACAL SALTS.)
es, forming the ammonium-salts of amic acids. (See

F. T. C.

AMMONIACAL SALTS. *Ammonium-salts, Sels ammoniacaux, Ammoniak-salze.*

Ammonia combines very readily with acids, which it neutralises completely, forming definite crystalline salts, known by the name of ammoniacal or ammonium-salts. These salts are isomorphous with those of potassium, and are in their general properties so closely analogous to metallic salts, that they are universally regarded as belonging to this class of bodies. There is, however, a characteristic difference in their mode of formation. While other metallic salts are formed by the substitution of a metal fo the hydrogen of an acid, *e.g.* chloride of zinc, $ZnCl = HCl + Zn - H$: ammoniacal salts are formed by the direct combination of ammonia with the acid, without elimination of hydrogen,—*e.g.* chloride of ammonium, $NH^4Cl = NH^3 + HCl$.

Among the various theories by which it has been proposed to represent the constitution of these salts, that which most clearly expresses their analogy with other metallic salts is unquestionably the *Ammonium Theory* of Berzelius. According to this theory, ammoniacal salts contain a compound metal, *ammonium*, NH^4, analogous to potassium, sodium, and other metals, the salts of which, *ammonium-salts*, are analogous to other metallic salts. Thus, chloride of ammonium, $ClNH^4$, is analogous to chloride of potassium, ClK; sulphate of ammonium, $SO^4(NH^4)^2$, to sulphate of potassium, SO^4K^2, &c. This hypothetical metal has never been isolated. An amalgam of mercury and ammonium is, however, known to exist, which affords strong corroborative evidence, not only of the existence of ammonium, but also of its metallic nature, metals being the only bodies which are capable of forming amalgams with mercury. This singular substance, discovered simultaneously in 1808, by Seebeck, at Jena, and by Berzelius and Pontin, at Stockholm, was originally prepared by the action of electricity upon aqueous ammonia in contact with mercury. A strong solution o aqueous ammonia in which mercury is placed, is brought into the voltaic circle, the negative pole dipping into the mercury, and the positive pole into the liquid. Another method is to dip the negative wire into mercury, which is placed in a cavity hollowed out of a fragment of a solid ammonium-salt, carbonate, sulphate, phosphate or chloride, the positive wire being inserted into the salt itself, or connected with a metallic plate on which the salt rests. Oxygen, or, if chloride of ammonium be employed, chlorine, is evolved at the positive pole, but scarcely any gas at the negative pole; while the mercury increases very largely in volume, and assumes the consistence of butter. When completely saturated with ammonium, the amalgam is lighter than water: obtained by the former method, it has frequently a crystalline structure. It is a very unstable compound, decomposing spontaneously as soon as it is removed from the voltaic circle, being resolved into liquid mercury, and a mixture of 2 vols. ammonia, NH^3, and 1 vol. hydrogen, H. When cooled below 0° C., it solidifies and crystallises in cubes. At a very low temperature, it contracts, and becomes brittle decomposition does not begin till the temperature rises to 29° C. According to Sir H Davy, it contains 1 atom NH^4 to 753 atoms mercury. The amalgam may also b prepared without the intervention of electricity, by bringing potassium- or sodium amalgam—the latter is more energetic in its action—into contact with an ammonium salt, either solid and moistened with water, or as a concentrated aqueous solution The amalgam thus prepared contains, according to Gay-Lussac and Thénard, 1 par nitrogen and hydrogen to 1800 parts mercury. It contains a certain portion of potassium or sodium, and on this account is less unstable than the amalgam prepared b either of the former methods: it may be preserved for a considerable time in anhydrous rock-oil, or in an atmosphere of hydrogen.

Formation.—Ammonium-salts are formed by bringing ammonia or carbonate of ammonium directly into contact with acids.

Properties.—Ammonium-salts are isomorphous with potassium-salts. They hav mostly a pungent, saline, somewhat urinous taste. They are all soluble in water generally with facility: less soluble in alcohol or ether. Ammonium-salts of colourle acids are colourless.

Reactions of Ammonium-salts. Tests for Ammonia.—Ammonium-salt are variously affected by heat: all, however, are wholly or partially volatilised, wit or without decomposition. The carbonate, and those which contain no oxygen (chloride iodide, &c.), are volatilised undecomposed. All others lose their ammonia when heate Some, *e.g.* the phosphate, and borate, evolve ammonia undecomposed, leaving the ac Others, *e.g.* sulphate, evolve nitrogen, the acid being more or less completely reduce by the hydrogen of the ammonia: the nitrate is decomposed into nitrous oxide an water. Their aqueous solution, when exposed to the air (still more rapidly whe evaporated), generally loses ammonia, an acid salt, or a normal salt mixed with exces of acid, being formed: hence, in crystallising an ammonium-salt, ammonia must b occasionally added during evaporation. When treated with *chlorine*, their aqueou solution yields hydrochloric acid and nitrogen; or, if the salt contains a powerful ac

of nitrogen (**Dulong**). With a solution *of hypochlorous*
water, chloride of nitrogen, and nitrogen, while nitrogen
(**Balard**). In solution they are decomposed by *pro-*
ionia; not by sesquioxides. When heated, either solid
i, baryta, lime, oxide of lead, &c., they evolve ammonia:
ammonia, forming a double salt.
nium-salts are generally detected, is their decomposition
r *alkaline earths.* If the ammonia evolved be in so minute
ic smell cannot be perceived, it is easily recognised by
e colour to reddened litmus-paper, and of forming dense
glass rod moistened with dilute hydrochloric acid. If
into contact with a strip of paper moistened with a dilute
mercury, sulphate of copper, or sulphate of manganese,
is produced on the paper, in the second a blue, in the
molybdate of sodium containing phosphoric acid (phos-
s with ammonium-salts, a yellow precipitate, soluble in
c acids, insoluble in mineral acids: in very dilute am-
n of the precipitate is gradual; it is accelerated by heat.
ammonium-salt or free ammonia is mixed with potash,
cury in iodide of potassium added, a brown precipitate
oduced (**Nessler**). $(NH^3 + 4HgI = NHg^4I + 3HI)$.
te test for ammonia.—With *dichloride of platinum,*
crystalline precipitate of chloroplatinate of ammonium,
ater, insoluble in alcohol or acids. When ignited, the
pure metallic platinum, perfectly free from chlorine.
or *tartaric acid*), they give a white precipitate of acid
soluble in cold water, readily soluble in alkaline solu-
ne carbonaceous residue left on igniting this precipitate
t too dilute solution of an ammonium-salt gives with a
e of aluminium, a crystalline precipitate of ammonium-
d solutions of ammonium-salts give precipitates with
Subnitrate of mercury gives a brown colour in solu-
.—A slightly alkaline solution of an ammonium-salt
hloride of mercury.—Alcoholic solutions of ammonium-
flame.
e just described, *e. g.* with phosphomolybdate of sodium,
ichloride of platinum, chloride of mercury, &c., are
s of methylamine, ethylamine, and other compound
es may, however, be distinguished with certainty from
e substance under examination with oxide of copper,
s into baryta water, when, if carbon is present, a
ta will be produced. (See ANALYSIS, ORGANIC, p. 225.)

tion of Ammonium.—Ammonium is separated from
aline metals, by its non-precipitation by hydrosulphuric
nmonium, or phosphate of sodium, in presence of chloride
and lithium it is separated by dichloride of platinum
s potassium and ammonium as chloroplatinates, while
solution. The mixed chloroplatinates are converted by
tallic platinum and chloride of potassium, the latter of
er, the solution evaporated to dryness, gently ignited,
platinum corresponding to the amount of potassium
rom the total weight of metallic platinum, the remaining
ium present: 1 atom of platinum corresponds to 1 atom
pplicable only when the metals are present as salts which
chlorides. Sulphates are best converted into chlorides
, and saturating the filtrate with hydrochloric acid.
eparation of ammonium from all other metals is to heat
tion in a combustion-tube with excess of soda-lime, and
in a bulb-apparatus containing hydrochloric acid. The
btained is mixed with excess of dichloride of platinum
d), and evaporated to dryness on a water-bath. The
, which dissolves excess of the dichloride: the chloro-
cted on a weighed filter, dried at 100° C., and weighed;
orcelain crucible into metallic platinum, from the weight
nia is readily calculated. This method is not applicable
from other volatile organic bases.
onally be estimated by loss. This is the case when the

ammonium-salt is entirely volatile, and when no other volatile or decomposible compound is present. The substance under examination is heated in a water-bath until it ceases to lose weight: it is then moderately ignited and weighed again, when the loss of weight represents the amount of ammonium-salt present. This is a convenient method for the estimation of chloride, nitrate, or normal sulphate of ammonium, in presence of the corresponding fixed alkaline salts.

Ammonia may also be estimated by distilling it into a known quantity of dilute acid, and determining volumetrically by a standard alkaline solution the excess of free acid.

The following are the principal ammonium-salts:

1. **Acetates of Ammonium.** *a. Normal acetate*, $C^2H^3O^2.NH^4$.—A white odourless salt, obtained by saturating glacial acetic acid with dry ammonia.

b. Acid acetate, $C^2H^3O^2.NH^4 + C^2H^4O^2$.—Obtained as a white crystalline sublimate, when dry powdered chloride of ammonium is treated with an equal weight of acetate of potassium or calcium, ammonia being given off simultaneously. (See Acetates, p. 12.)

2. **Carbonates of Ammonium.**—H. Rose (Pogg. Ann. xlviii. 352) admits the existence of a considerable number of carbonates of ammonium, to which he assigns very various and complicated formulæ. But, according to H. Deville (Compt. rend. xxxiv. 880; Ann. Ch. Phys. [3] xl. 87), there exist only two carbonates of ammonium of definite composition.

a. Normal carbonate, $CO^3(NH^4)^2$ [or $CO^2.NH^4O = CO^2.NH^3.HO$].—This salt has never been isolated. The salt which crystallises from an alcoholic solution of sesquicarbonate of ammonium saturated with ammonia, is simply sesquicarbonate. Neither can it be obtained from a saturated solution of commercial sesquicarbonate in strong aqueous ammonia. It may be obtained in aqueous or alcoholic solution, or, as sesquicarbonate, in combination with the acid carbonate (*b*). (Pelouze et Fremy, Traité de Chimie, ii. 222.)

b. Acid carbonate, $CO^3.NH^4.H$ [or $CO^2.NH^4O + CO^2.HO$.]—Obtained by saturating an aqueous solution of ammonia or sesquicarbonate of ammonium with carbonic anhydride. Or by treating the commercial sesquicarbonate finely powdered, with alcohol of 90 per cent., which dissolves out normal carbonate, leaving a residue of acid carbonate. Sesquicarbonate of ammonium is similarly decomposed by cold water; but in this case, a larger quantity of the acid carbonate is dissolved. All carbonates of ammonium, when left to themselves, are gradually converted into acid carbonate. It forms large crystals, belonging to the right prismatic or trimetric system. According to Deville, it is dimorphous, but never isomorphous with acid carbonate of potassium. When exposed to the air, it volatilises slowly, without becoming opaque, and gives off a slight ammoniacal odour. At the ordinary temperature, it is soluble in 8 parts of water; if this solution be heated above 36° C. it is decomposed, evolving carbonic anhydride. Even at ordinary temperatures, the solution, whether concentrated or dilute, gradually becomes ammoniacal on keeping (Gmelin). It is insoluble in alcohol: but when exposed to the air under alcohol, it dissolves as normal carbonate, evolving carbonic anhydride.

It has been found native in considerable quantity in the deposits of guano on the western coast of Patagonia, in the form of white crystalline masses, with a strong ammoniacal smell. (Ulex. Ann. Ch. Pharm. lxvi. 44.)

c. Sesquicarbonate, $C^3O^9N^4H^{18} + 2H^2O$ [$= 3CO^2.2NH^4O + 3HO$.]—Obtained by dissolving commercial carbonate of ammonium in strong aqueous ammonia, at about 30° C., and crystallising the solution. It forms large transparent crystals, representing a right rectangular prism, with the faces of the corresponding rhombic octahedron resting on the angles. These crystals decompose very rapidly in the air, losing water and ammonia, and being converted into di-acid carbonate. This salt may be regarded as a mixture or compound of 1 atom of normal carbonate with 2 of atoms acid carbonate [$CO^3.(NH^4)^2 + 2(CO^3.NH^4.H) = C^3O^9N^4H^{18}$]: a view which is confirmed by its behaviour with water and alcohol; which, when added in quantity insufficient for the complete solution of the salt, dissolves out normal carbonate, leaving a residue of acid carbonate: 100 pts. water at 13° C. dissolve 25 pts. sesquicarbonate, at 17°, 30 pts.; at 32°, 37 pts.; at 41°, 40 pts.; at 49°, 50 pts. (Berzelius): above this temperature, carbonic anhydride is evolved, and a solution of normal carbonate formed.

Commercial carbonate of ammonium (*sal volatile*, *salt of hartshorn*, &c.) consists of sesquicarbonate, more or less pure. It is prepared on a large scale by the dry distillation of bones, hartshorn, and other animal matter. The product thus obtained is contaminated with empyreumatic oil, from which it is purified by subliming it once or twice with 1½ times its weight of animal charcoal, in cast-iron vessels over which glass receivers are inverted. By repeated sublimation, the salt is partially decomposed. Another method of preparing it is by heating to redness a mixture of 1 pt. chloride or sulphate of ammonium, and 2 pts. carbonate of calcium (chalk), or carbonate of potassium,

r is luted: ammonia and water are first disengaged, and
ils over and solidifies in the neck of the retort and the
lass vessels are employed: on a large scale, an earthenware
earthenware or leaden receiver, which, when filled by
en or cut in two: 10 pts. sal-ammoniac yield from 7 to 8
ictionary of Arts, Manufactures and Mines, i. 135.) The
contain the following impurities:
n: when sulphate of ammonium, or chloride containing
preparation. The salt neutralised with acetic acid gives
urns black on addition of nitrate of silver.—*Sulphate of*
ses: detected by hydrochloric acid and chloride of barium.
nitric acid and nitrate of silver.—*Lead*, from the receiver:
d when dissolved in dilute nitric acid, gives the reactions
of calcium, carried over mechanically: from these and
is freed by re-sublimation.

ned as above is a white, transparent, fibrous mass, with
a strong ammoniacal smell. Exposed to the air, it is
carbonate. It is completely volatile, though not without
ueous solution is strongly alkaline: from a hot saturated
rystallises on cooling, but not in the ordinary crystalline

s salt (*spiritus salis ammoniaci*), is extensively employed
It is also a very valuable reagent. The solid salt is
of other ammoniacal salts.

, $ClNH^4$. (*Hydrochlorate* or *muriate of ammonia*, *Sal-*
iak, *Salmiak*, *Chlorure d'ammonium*, or *Chlorure am-*

ammonia combine volume for volume, with great evolu-
oride of ammonium. This salt forms colourless feathery
ned by a lens, are found to consist of an aggregation of
no smell, but a pungent taste; its specific gravity is 1·5.
at 18·75° C., with great reduction of temperature; and in
r at 100°. It is less soluble in alcohol. When exposed
and becomes acid to test-paper. When heated, it vola-
ut previous fusion. After sublimation, it forms white
exceedingly tough and difficult to powder: to obtain it
saturated solution is evaporated to dryness very rapidly,
n the salt is left as a crystalline powder.

decomposed by several metals, potassium, iron, &c., a
ed, and ammonia and hydrogen separated. It is also
by some, *e.g.* alkaline and alkaline-earthy hydrates,
volved; by others, as by cupric and ferric salts, partially,
Some salts, *e.g.* platinic chloride, combine with it
s (chloroplatinates). Some metallic hydrates are soluble
, especially those of zinc and magnesium.

ive in many volcanic regions; also in small quantities in
med by heating nitrogenised animal matter containing
hich that salt has been mixed. Until the middle of the
as obtained almost exclusively from Egypt, where it was
ubliming the soot obtained by the combustion of camel's
nufactured in Europe, chiefly from the impure carbonate
ined in gas-works, or by the dry distillation of animal
converted into chloride by the addition of hydrochloric
r from salt-works, containing the chlorides of magnesium
ng the solution (ammonia being added from time to time),
obtained. These are contaminated with empyreumatic
eating the crystals to a temperature a little below their
hen dissolved in water, the solution decolorised by boiling
ain crystallised. The salt is finally purified by sublima-
a brisk heat, in large glass or earthenware bottles, the
lly kept unobstructed, to avoid the risk of explosion: the
the sal-ammoniac removed in cakes. Metallic receivers
he sublimation; in this case, the outer surface of the sal-
wing to metallic impurities, and must be scraped off.

e carbonate of ammonium is first converted into sulphate,
ide. This is generally done by filtering the solution of
of powdered gypsum (sulphate of calcium), when insoluble

carbonate of calcium is formed, and a solution of sulphate of ammonium obtained. This solution is mixed with chloride of sodium, evaporated to dryness, and the sal-ammoniac separated from the residue by sublimation. Or the solution of the two salts is evaporated at the boiling heat, when sulphate of sodium, being less soluble at a high than at a lower temperature, mostly crystallises out and is removed. The solution is then cooled, when the sal-ammoniac crystallises out, since its solubility diminishes rapidly with decrease of temperature. The crystals thus obtained are purified as above described. Ferrous sulphate may be employed instead of gypsum to convert the carbonate of ammonium into sulphate; this is a more expensive process, but it possesses the advantage of removing the greater part of the empyreumatic oil, which is carried down by the precipitated iron-salt. (Berzelius.)

In the factory at Buxweiler, in Alsace, sal-ammoniac, phosphorus, and gelatin are prepared by the following ingenious process. Bones are digested in hydrochloric acid, which dissolves out the bone-earth, leaving the cartilage insoluble: the latter is employed for the preparation of gelatin. The hydrochloric solution is mixed with crude carbonate of ammonium, when sal-ammoniac is formed, and phosphate of calcium precipitated in the finely-divided state in which it is best adapted for the preparation of phosphorus. [For further details of the manufacture of sal-ammoniac, see *Dictionary of Arts, Manufactures and Mines*, i. 141.]

Sal-ammoniac is employed in medicine. In the laboratory it serves for the preparation of ammonia, and carbonate of ammonium, and for frigorific mixtures. It is employed in dyeing; also in metal-works, as a deoxidising agent, especially for copper. A solution of chloride of silver in chloride of ammonium is employed for plating copper and brass. It enters into the composition of a cement used for fixing iron in stone: this cement is formed by moistening with a solution of sal-ammoniac, iron-filings mixed with 1 or 2 per cent. sulphur. Impure sal-ammoniac has recently been employed as manure.

4. HYDRATE OF AMMONIUM, $\mathrm{NH^4.H.O}$.—This compound has never been isolated. The aqueous solution of ammonia behaves in many respects like a solution of hydrate of ammonium.

5. NITRATE OF AMMONIUM, $\mathrm{NO^3.NH^4}$ [or $NO^5.NH^4O = NO^5.NH^3.HO$]. (*Nitrum flammans.*)—Obtained by crystallising a mixture of nitric acid with a slight excess of aqueous ammonia. It forms long flexible needles: if the crystallisation be effected very slowly, it may be obtained in six-sided prisms. When the solution is evaporated to a very small bulk, the salt solidifies into a dense amorphous mass. It has a pungent taste. It is soluble in about half its weight of water at 18° C., and in still less at 100°: its saturated solution boils at 164° C., and contains 47·8 per cent. salt: when dissolved in water it produces great cold. It is soluble in alcohol. Exposed to the air, it deliquesces slightly, loses ammonia, and becomes acid. When heated, it fuses perfectly at 108° C., and boils without decomposition at 180°. Between 230° and 250° it is decomposed into water and nitrous oxide, ($\mathrm{NO^3.NH^4 = N^2O + 2H^2O}$). If it be heated too rapidly, ammonia, nitric oxide, and nitrite of ammonium are also formed. (Berzelius). When thrown into a red-hot crucible, it burns with a slight noise, and a pale yellow flame. In presence of spongy platinum, it is decomposed at about 170° C. into nitrogen and nitric acid. (Millon and Reiset.)

Nitrate of ammonium is formed when a mixture of nitrogen, oxygen, and excess of hydrogen is submitted to the electric current; also when hydrosulphuric acid is passed into a dilute solution of nitric acid. It is also formed by the action of nitric acid on several metals, especially tin.

6. NITRITE OF AMMONIUM, $\mathrm{NO^2.NH^4}$ [$= NO^3.NH^3.HO$].—Obtained by double decomposition of nitrite of lead and sulphate of ammonium, or of nitrite of silver and chloride of ammonium: the solution is evaporated in vacuo. Or by passing nitrous fumes into aqueous ammonia, and evaporating over lime (Millon). It forms an imperfectly crystallised mass. It is decomposed by heat into nitrogen and water, ($\mathrm{NO^2.NH^4 = N^2 + 2H^2O}$). Its aqueous solution is similarly decomposed, suddenly if acid, gradually if alkaline.

7. OXALATES OF AMMONIUM. —*a. Normal oxalate.* $\mathrm{C^2O^4(NH^4)^2 + H^2O}$.—Obtained by neutralising oxalic acid with ammonia, and crystallising. It forms long prisms united in tufts, belonging to the rhombic, right prismatic or trimetric system: soluble in 3 pts. cold water, insoluble in alcohol. It is very slightly volatile at ordinary temperatures. When carefully heated to 220° C. it is entirely decomposed into carbonic oxide and carbonate of ammonium; when it is heated more strongly, some oxamide is formed. Its solution is employed as a reagent for precipitating calcium-salts.

b. Acid oxalate, $\mathrm{C^2O^4.NH^4.H + H^2O}$. – Obtained in the crystalline form by adding oxalic, sulphuric, nitric, or hydrochloric acid to a solution of the normal salt. It crystallises in the trimetric system. It reddens litmus, and is less soluble than the normal at, yielding, among other products, oxamide, $C^2O^2N^2H^4$,

oxalate, $C^2O^4.NH^4.H + C^2O^4H^2 + 2H^2O$. — Obtained
ual parts of acid oxalate and oxalic acid. The crystals
y oblique prismatic system, and are isomorphous with
alt. They are very soluble in hot water. At 100° C.
e their water of crystallisation.

M. — *a. Normal phosphate*, $PO^4(NH^4)^3$ [or $PO^5.3NH^4O$.]
d phosphate of ammonium is mixed with ammonia,
ne magma: it cannot be dried without losing ammonia,

$^4.(NH^4)^2.H$ [or $PO^5.2NH^4O.HO$]. (*Ordinary phosphate*
neutral phosphate.)—Obtained by adding a slight excess
monium to acid phosphate of calcium (solution of bone-
lphuric acid); when phosphate of calcium is precipitated,
onium remains in solution. It forms large, colourless,
to the monoclinic or oblique prismatic system. It has
alkaline reaction. Exposed to the air, it effloresces
is soluble in 4 pts. cold, and in a smaller quantity of
hol. By a red heat, it is converted into metaphosphoric
$2NH^3 + H^2O$).
$PO^4.(NH^4).H^2$ [or $PO^5.NH^4O.2HO$]. (Formerly called
adding phosphoric acid to aqueous ammonia, till the
longer precipitates chloride of barium; or by boiling
ating it to crystallisation. It crystallises in the dimetric
It is somewhat less soluble in water than *b*, and is

n are employed for the preparation of metaphosphoric
gnition always retains ammonia, it must be moistened
cined. Gay-Lussac has proposed to preserve muslins
from ignition by steeping them in a solution of these
l by heat, the tissue is covered with a film of metaphos-
from contact with the air, and prevents its breaking
ot, however, be applied to fabrics which have to be
heat of the iron would decompose them, expelling the
applies to sulphate of ammonium, which is otherwise
flammability of light tissues. From recent experiments
eim (Pharm. J. Trans. [2] i. 385), it appears that the
e for rendering such fabrics non-inflammable, is the
See TUNGSTATES.)
es of ammonium and other metals are of considerable
sodium, ammonium and hydrogen, $PO^4.Na.NH^4.H$, com-
or *phosphorus salt*, is much used as a blow-pipe flux,
transparent metaphosphate of sodium, which dissolves
cteristic colours.

. — *a. Normal Sulphate*, $SO^4(NH^4)^2$ [or $SO^3.NH^4O$.]
btained by neutralising dilute sulphuric acid with
nium. It forms crystals belonging to the trimetric or
hous with potassic sulphate. It is colourless, and has
le in twice its weight of cold, and in its own weight of
hol. It fuses at 140° C: above 280°, it is decomposed,
r being given off, and acid sulphite of ammonium

nine. It is manufactured on a large scale (as already
) by neutralising with sulphuric acid, or decomposing
te of ammonium obtained in gas-works, &c. and crys-
stals are heated, to destroy animal matter, and purified
of ammonium is employed in the manufacture of am-

[or $2SO^3.NH^4O.HO$].—Obtained by treating a solution
crystallises in thin rhombohedrons. It is soluble in its
in alcohol. It deliquesces slowly in the air.

a.—*a. Sulphide*, $(NH^4)^2S$.—When a mixture of dry hy-
a, the latter in excess, is exposed to a temperature of
bine with 1 vol. hydrosulphuric acid, and form sulphide
pound is formed when sulphide of potassium is distilled

with chloride of ammonium, provided the receiver be cooled to −18° C. It form colourless crystals, which have a strong alkaline reaction. At the ordinary temperatur it is at once decomposed, losing ammonia, and being converted into sulphydrate (b This decomposition takes place even in an atmosphere of ammonia. Its aqueous solu tion, which is much employed as a reagent, is prepared by dividing a saturate solution of ammonia into 2 equal parts, saturating one with hydrosulphuric acid, an then adding the other. It forms a colourless solution, which becomes yellow keeping, owing to the formation of a higher sulphide; by further exposure to th air, sulphur is separated, hyposulphite, sulphite, and finally sulphate of ammoniu being successively formed.

b. Sulphydrate or *Hydrosulphate*, $NH^4.H.S.$—Obtained by mixing dry hydrosu phuric acid and ammonia, in any proportions, at a temperature above −18° C. is a combination of the two gases in equal volumes. It forms colourless crystals, whic have an alkaline reaction, and volatilise undecomposed, even at ordinary temperature Its aqueous solution is obtained by saturating aqueous ammonia with washed hydrosu phuric acid, out of contact with the air. It forms a colourless solution, which, by e posure to the air, is decomposed in the same manner as the sulphide.

c. Polysulphides.—Besides the above, there are several other compounds of sulph and ammonium described, which may be regarded as combinations of the monosu phide with sulphur, or as polysulphides of ammonium. These are—1. The *disulphi* $(NH^4)^2S^2$; 2. The *trisulphide*, $(NH^4)^2S^3$; 3. The *tetrasulphide*, $(NH^4)^2S^4$; 4. T *pentasulphide*, $(NH^4)^2S^5$; 5. The *heptasulphide*, $(NH^4)^2S^7$. The most general meth of preparing these compounds is by distilling the corresponding sulphide of potassi with excess of chloride of ammonium. In the wet way, they are prepared by addi sulphur to a solution of the monosulphide, and saturating the mixture alternately w ammonia and hydrosulphuric acid. The heptasulphide, to which there is no cor sponding sulphide of potassium, is formed by the spontaneous decomposition of pentasulphide:

$$3(NH^4)^2S^5 = 2(NH^4)^2S^7 + NH^3 + NH^4.H.S.$$

It forms ruby-red crystals. It is the most stable of the polysulphides of ammoniu not being decomposed at temperatures below 300° C., and but very slowly by water hydrochloric acid.

The substance known as *fuming liquor of Boyle*, or *volatile liver of sulphur*, i mixture of two or more sulphides of ammonium. It is obtained by distilling a m ture of 1 pt. sulphur, 2 pts. sal-ammoniac, and 2 to 3 pts. quick lime. It is a d yellow liquid, of penetrating smell: it fumes strongly in the air, or in any gas c taining oxygen, not in gases free from oxygen. It is capable of taking up m sulphur, forming a syrupy fluid, which no longer fumes on contact with air.—F. T

AMMONIUM. A hypothetical metal, whose composition is expressed by formula NH^4: it is supposed to be contained in ammoniacal salts. (See Am niacal Salts, p. 188.)

AMMONIUM-AMALGAM. (p. 188.)

AMMONIUM-BASES. In very many cases, the watery solution of ammo behaves with other bodies exactly like a solution of potash or soda. We can express this similarity in our chemical formulæ, if we regard liquid ammonia as a n solution of ammonia, NH^3, in water: it only becomes comparable to the fixed alk when we regard it as containing a compound of ammonia with water, $NH^3.H^2O$. order to express this relation still more precisely, Berzelius proposed to repre aqueous ammonia as containing the hydrated oxide of the compound group, NH $\left(NH^3.H^2O = \left.\begin{matrix}NH^4\\H\end{matrix}\right\}O\right)$, to which he gave the name *Ammonium*, and by means of w the ammonia-salts can be represented as exactly analogous to those of potassi sodium, or the metals generally (see Ammonium-Salts, p. 188). In the ar Amides, it is shown that a very large number of bodies may be formed from ammo by replacing a part or the whole of its hydrogen by other radicles, simple or compo When the hydrogen of ammonia is replaced by the alcohol-radicles (methyl, e &c.), or by other bodies which more or less resemble hydrogen in their ger chemical characters, the resulting compounds (*Amines*) retain the most impor property of ammonia itself, namely, the property of forming definite salts by d union with acids. It is evident that, if it is wished to express the analogy of the of these derivatives of ammonia with the metallic salts, they may be represent containing ammonium in which part of the hydrogen is replaced by other radi for instance, hydrochlorate of triethylamine, $NC^6H^{16}Cl$, may be viewed as chlori triethylammonium, $[N(C^2H^5)^3H]Cl$, analogous to chloride of ammonium, $(NH^4)Cl$ chloride of potassium, KCl.

of the hydrogen of the ammonium in ammonia-salts is
er fourth belonging to the acid, it is plain that the
nonias with acids never represent ammonium-salts in
f the hydrogen is replaced. But, by the combination
of ammonia by the replacement of all three atoms of
milar radicles), with the chlorides, bromides, or iodides
nds are formed which represent ammonium-salts in
ed by other radicles (see Amides, p. 175): *e. g.*

$$\underset{\text{lamine.}}{{}^2H^5)^3} + \underset{\text{Iodide of ethyl.}}{C^2H^5.I} = \underset{\text{Iodide of tetrethylium.}}{N.(C^2H^5)^4I}$$

analogy of this mode of formation to the formation of
ion of the iodides, &c, of alcohol-radicles on am-

$$\underset{\text{lide of thyl.}}{{}^2H^5I} = \underset{\text{Hydriodate of ethylamine.}}{N.(C^2H^5.H^3)I;}$$

class of bodies with the ammonium-salts: —

I, hydriodate of ammonia, or iodide of ammonium,
I, „ ethylamine, „ ethylium,
I, „ diethylamine „ diethylium,
I, „ triethylamine „ triethylium,
I, iodide of tetrethylium;

onium-theory to express the nature of the salts of the
he derivatives of the ammonium-salts by the replace-
mmonium, nevertheless exhibit some important general
amines. For example, when caustic potash or lime is
an amine, the salt is decomposed, even in the cold, and
t liberty; on the other hand, iodide of tetrethylium,
ecomposed by potash; it can however be decomposed
en, there is no separation of a derivative of ammonia,
$^2H^5)^4.H.O$, or a similar body, is formed:

$$AgHO = \underset{\text{Hydrate of tetrethylium.}}{N(C^2H^5)^4.H.O} + AgI.$$

ammonium, which may be supposed to be formed in
composed into ammonia and water: in the second case,
ydrate of ammonium is stable and has the properties
e makes it convenient to have some general term to dis-
f tetrethylium from such basic hydrates as decompose,
n, into a representative of ammonia and water. The
efore often spoken of as *ammonium-bases*, in contra-
onia-bases.

ium-bases is specially interesting in connection with
mpossible to isolate the hydrate of ammonium, which,
in solution of ammonia, or to obtain a corresponding
ound ammonias; but the ammonium-bases are repre-
um, which correspond to the hydrates of potassium
ormulæ, but very closely in their properties. Their
to the touch; by evaporation, they are obtained as
ble in water, which liberate ammonia from its salts,
des which are soluble in potash, and decompose com-
ing acid and alcohol. At a high temperature, they
f a tertiary amine:

$$= \underset{\text{Triethylamine.}}{N.(C^2H^5)^3} + \underset{\text{Ethylene.}}{C^2H^4} + H^2O.$$

are similarly decomposed by **heat**:

$$\underset{\text{of um.}}{{}^5)^4I} = \underset{\text{Triethylamine.}}{N(C^2H^5)^3} + \underset{\text{Iodide of ethyl.}}{C^2H^5.I.}$$

osphide, arsenide, and antimonide of hydrogen, give
nds by combination with hydriodic ethers and subse-

quent decomposition of the iodide so formed, by hydrate of silver. The decomposit by heat of the hydrates of the *phosphonium-bases*, differs from that of the correspo ing ammonium-bases: *e. g.*

$$P(C^2H^5)^4H.O = P(C^2H^5)^3O + C^2H^5.H.$$

Hydrate of tetrethyl-phosphonium. Oxide of triethylphosphine. Hydride of ethyl.

POLYAMMONIUM-BASES.—These compounds bear to the monammonium-b just described, the same relation that the diamines and triamines bear to the m amines: they may be considered as representing two or more molecules of hydrat ammonium in which the whole or part of the hydrogen is replaced by polyato radicles. As in the case of the monammonium-bases, there is a difference between polyammonium-bases in which only part of the hydrogen is replaced, and thos which it is all replaced: the former cannot be obtained in the isolated state; the la are stable compounds and possess strong alkaline properties. But both these cla of hydrates have been less studied, and are therefore hitherto less important, than corresponding salts, which are for the most part equally stable, whether still contai replaceable hydrogen, or no. We shall therefore in this article treat of the p ammonium compounds generally, making no essential distinction between hydr and other salts, or between those compounds in which the hydrogen of ammoniu wholly, and those in which it is partially replaced. Moreover, as the bodies of class containing phosphorus and arsenic have been at least as much studied as t containing nitrogen, it will be most convenient to speak of the action of polyato compounds on the basic derivatives of ammonia generally, taking as special exam of the various reactions hitherto known, compounds containing nitrogen, phospho or arsenic, as these or those happen to be best known.

A. ACTION OF DIATOMIC CHLORIDES, BROMIDES, OR IODIDES: —

1. *On Ammonia.*

The experiments which have been made in this direction are almost confine the action of bromide of ethylene on ammonia. The products thus formed are following:

Dibromide of ethylene-diammonium . . . $N^2(\overset{\prime\prime}{C^2}H^4)H^6Br^2$

Dibromide of diethylene-diammonium . . . $N^2(\overset{\prime\prime}{C^2}H^4)^2H^4Br^2$

Dibromide of triethylene-diammonium . . . $N^2(\overset{\prime\prime}{C^2}H^4)^3H^2Br^2$.

These compounds, when distilled with potash, give, respectively, ethylenam $N^2(\overset{\prime\prime}{C^2H^4})H^4$, diethylenamine, $N^2(\overset{\prime\prime}{C^2}H^4)^2H^2$, and triethylenamine, $N^2(\overset{\prime\prime}{C^2}H^4)^3$, bo which are likewise acted on by bromide of ethylene, the final product being a subst very analogous to bromide of tetrethylium, and which is probably dibromid tetrethylene-diammonium, $N^2(\overset{\prime\prime}{C^2}H^4)^4Br^2$.

2. *On Primary derivatives of ammonia, primary amines.*

Bromide of ethylene gives with ethylamine and phenylamine:

Dibromide of ethylene-diethyl-diammonium . . $N^2(\overset{\prime\prime}{C^2}H^4)(C^2H^5)^2H^4Br^2$

Dibromide of diethylene-diethyl-diammonium . $N^2(\overset{\prime\prime}{C^2}H^4)^2(C^2H^5)^2H^2Br^2$

and similar phenyl-compounds.

3. *On Tertiary derivatives of ammonia.*

Just as dibasic acids can combine with one or with two atoms of ammonia, so wise can diatomic ethers (such as chloride or bromide of ethylene, or iodide of me lene) combine with one or with two atoms of the tertiary derivatives of ammo Thus triethylphosphine with bromide of ethylene gives the compounds —

$\left.\begin{matrix}(C^2H^4)''Br^2\\(C^2H^5)^3P\end{matrix}\right\}$ "Bromide of bromethyl-triethylphosphonium" (Hofmann).

$\left.\begin{matrix}(C^2H^4)''Br^2\\2[(C^2H^5)^3P]\end{matrix}\right\}$ "Bromide of ethylene-hexethyl-diphosphonium" (Hofmann

The condition of the bromine contained in these compounds is worth noticing. addition of nitrate of silver to a solution of the first compound precipitates only the bromine contained in it, but nitrate of silver precipitates all the bromine conta in the second. This difference is explained by Hofmann, by supposing that 1 ato

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* Bromide of ethylene and iodide of methylene combine directly with only 1 atom of the te amines, but the compounds with two atoms can be obtained by the action of hydrobromic, or hyd ethers on ethylenamine.

is contained in the form of *bromethyl*, C^2H^4Br: his
two compounds is expressed in the names quoted
ult to account for the difference in the behaviour of
ng this supposition. When we remember that the
not precipitated by nitrate of silver, but that it
of ethyl is combined with ammonia or an analogous
that *one* of the two atoms of bromine in bromide of
or accessible to ordinary reagents) when that body is
a representative of ammonia, and that *both* atoms
ombined with two molecules of an ammonia-deriva-
pon the model of the first compound, only 1 atom of
nitrate of silver; in all those formed upon the model
cipitable.

ortant transformations of the above or similar bodies.

decomposed by heat thus:—

$$\left.\begin{array}{r} {}^{2} \\ \mathrm{P} \end{array}\right\} = \mathrm{HBr} + \left.\begin{array}{l} C^2H^3Br \\ (C^2H^5)^3P \end{array}\right\}$$

Bromide of vinyl-tri-
ethylphosphonium.

reated with hydrate of silver, it loses all its bromine

nay be regarded as a compound of triethylphosphine

strong base, but, as in the bromine compound, only
d with the ethylene, are directly replaceable by acid
ives $\left.\begin{array}{l} C^2H^4.HO.Cl \\ (C^2H^5)^3P \end{array}\right\}$): with bromide of phosphorus, it
compound. In a concentrated solution, hydrate of

from the last substance by the elements of an atom of

egarded as containing oxide of ethylene and triethyl-
ame class of bodies as the bases * which Wurtz ob-
on oxide of ethylene:—

$$\left.\begin{array}{r} 2(C^2H^4.O) \\ H^3N \end{array}\right\} \qquad \left.\begin{array}{r} 3(C^2H^4.O) \\ H^3N \end{array}\right\}$$

Diethylene-dihydoramine. Triethylene-trihydoramine.

verted by acetate of silver at 100° C. into acetate of
$H^5)^3C^2H^3.C^2H^3O^2$. This reaction probably has two

$$+ 2(C^2H^3AgO^2) = \left.\begin{array}{l} C^2H^4.(C^2H^3O^2)^2 \\ (C^2H^5)^3P \end{array}\right\} + 2AgBr$$

$$)^2\Big\} = \left.\begin{array}{l} C^2H^3.C^2H^3O^2 \\ (C^2H^5)^3P \end{array}\right\} + C^2H^4O^2$$

of the reaction is precisely similar to the decomposi-
omine-compound by heat.

onverted into bromide of tetrethylphosphonium:—

$$\left.\begin{array}{r} r^2 \\ {}^3P \end{array}\right\} + H^2 = \left.\begin{array}{l} C^2H^5Br \\ (C^2H^5)^3P \end{array}\right\} + HBr$$

ia, it gives bodies of the type of the second compound.
o obtained.

$$\left.\begin{array}{r} {}^{2} \\ P \\ N \end{array}\right\}, \left.\begin{array}{l} C^2H^4Br^2 \\ (C^2H^5)^3P \\ (CH^3)^3N \end{array}\right\}, \left.\begin{array}{l} C^2H^4Br^2 \\ (C^2H^5)^3P \\ (CH^3)^3P \end{array}\right\}, \left.\begin{array}{l} C^2H^4Br^2 \\ (C^2H^5)^3P \\ (C^2H^5)^3P \end{array}\right\}, \left.\begin{array}{l} C^2H^4Br^2 \\ (C^2H^5)^3P \\ (C^2H^5)^3As \end{array}\right\}$$

t bodies of this class part with all their bromine to
er gives $\left.\begin{array}{l} C^2H^4.H^2.O^2 \\ 2[(C^2H^5)^3P] \end{array}\right\}$ and similar bodies. These
responding salts by the action of acids. $\left.\begin{array}{l} C^2H^4.H^2.O^2 \\ 2[(C^2H^5)^3P] \end{array}\right\}$
$\left.\begin{array}{l} H^4O \\ H^5)^3P \end{array}\right\}$, a compound already mentioned, and oxide of

---

ing from the mixed type $\left.\begin{array}{l} nH^2O \\ mH^3N \end{array}\right\}$, namely *amic bases* and *amic*
oramides (not to be confounded with hydramides) may be used

triethylphosphine, $P(C^2H^5)^3O$.—$\left.\begin{matrix}C^2H^4Br^2\\(C^2H^5)^3P\\(C^2H^5)^3As\end{matrix}\right\}$ is decomposed by heat into $\left.\begin{matrix}C^2H^4Br^2\\(C^2H^5)^3P\end{matrix}\right\}$ an
triethylarsine, $(C^2H^5)^3As$.

B. Action of Triatomic Chlorides, Bromides, or Iodides: —

1. *On Ammonia.*

Tribromide of glyceryl, $(\overset{'''}{C^3H^5})Br^3$, gives with ammonia a base containing NC^6H^9Br
and bromide of ammonium. The reaction probably takes place according to th
following stages: —

$$1° \quad C^3H^5Br^3 = C^3H^4Br^2 + HBr.$$
$$2° \quad 2(C^3H^4Br^2) + NH^3 = NC^6H^9Br^2 + 2HBr,$$

the hydrobromic acid which is formed of course combining with ammonia. The fir
stage of the reaction is analogous to the conversion of bromide of ethylene into bron
ethylene by the action of alcoholic potash: the compound, $C^3H^4Br^2$ may be regarde
as dibrom-propylene, or as bromide of brom-allyl, $(C^3H^4Br)'Br$. In the latter ca

the product of its action on ammonia becomes $N\left\{\begin{matrix}(C^3H^4Br)'\\(C^3H^4Br)'\\H\end{matrix}\right.$ *dibrom-diallylamin*

(Maxwell Simpson).

2. *On Primary derivatives of ammonia.*

Chloroform, $(\overset{'''}{C}H)Cl^3$, reacts on phenylamine, forming the hydrochlorate of a monoac
base, containing, $C^{13}H^{12}N^2$, and which may be considered as representing two molecu

of phenylamine in which the radicle $(\overset{'''}{C}H)$ replaces H^3; thus $\left.\begin{matrix}(\overset{'''}{C}H)\\(C^6H^5)^2H\end{matrix}\right\}N^2$.

3. *On Tertiary derivatives of ammonia.*

Iodoform, $(\overset{'''}{C}H)I^3$, combines with three molecules of triethylphosphine, givi
$\left.\begin{matrix}CH.I^3\\3[(C^2H^5)^3P]\end{matrix}\right\}$. This compound parts with all its iodine to silver-salts, which accor
with what is said above respecting the compounds of bromide of ethylene with tr
thylphosphine. Its solution treated with hydrate of silver does not give a correspon
ing hydrate, but hydrate of methyl-triethylphosphonium and oxide of triethylph
phine.

$$\begin{matrix}(\overset{'''}{C}H)I^3\\3[(C^2H^5)^3P]\end{matrix} + 3AgHO = \left.\begin{matrix}CH^3.HO\\(C^2H^5)^3P\end{matrix}\right\} + 2[(C^2H^5)^3P.O] + 3AgI.$$

C. Action of Tetratomic Chlorides, Bromides, or Iodides on Derivati
of Ammonia.

Bichloride of carbon, $(\overset{iv}{C})Cl^4$, reacts on phenylamine thus: —

$$\underset{\text{3 mol. phenylamine.}}{3(C^6H^7N)} + CCl^4 = 3HCl + C^{19}H^{17}N^3.HCl.$$

The product of this reaction may be regarded as the hydrochlorate of a base
riving from three molecules of phenylamine by the substitution of $(\overset{iv}{C})$ for H^4: viz.

$$\left.\begin{matrix}(\overset{iv}{C})\\(C^6H^5)^3\\H^2\end{matrix}\right\}N^3.$$

(For details, see various papers by Hofmann, Proc. Roy. Soc. vols. ix. and x., a
the Articles Phosphorus, Arsenic, Antimony.)

Ammonium-bases containing Metals.—A very large number of compou
have been obtained by treating different metallic salts with ammonia. Some of th
compounds are apparently of similar constitution to the salts of the organic ammoniu
bases, or to easily conceivable derivatives of them. But it is impossible to reduce
greater number of them to any consistent system, before they have themselves b
more thoroughly examined, and we have more definite notions as to the atomicity
the metals contained in them. The following are examples of some of these co
pounds which can be written as analogous to known or conceivable organic co
pounds.

Organic Analogues.

. . . . $N.H^3.C^2H^5.Cl$

. . . . $N.H^2(C^2H^5)^2Cl.$

. . . . $N^2H^4(\overset{\prime\prime}{C}{}^2H^4)^2.Cl^2.$

. . . . $N(C^2H^5)^4Cl.$

. . . . $N^2(\overset{\prime\prime}{C}{}^2H^4)^4Cl^2.$

. . . . $N(CH^3)^2\,(\overset{\prime\prime}{C}{}^2H^4)Br^2.$

. . . $\begin{array}{l} N \\ O \\ I \end{array}\left\{\begin{array}{l} H^2 \\ (\overset{\prime\prime}{C}{}^2H^4)\text{ (unknown.)} \\ (\overset{\prime\prime}{C}{}^2H^4). \end{array}\right.$

. . . . $P(C^2H^5)^2\,(\overset{\prime\prime}{C}{}^2H^4)Br^2.$

. . . . $P^2(C^2H^5)^6(\overset{\prime\prime}{C}{}^2H^4)Br^2.$

made by some chemists to make formulæ for many
ammonium-salts, by supposing ammonium capable of
n, or by assuming the existence of such radicles as
in words used with reference to another subject, by
, as "unwissenschaftliche Spielereien, die hier keine
G. C. F.

See ALLANTOIC and AMNIOTIC LIQUIDS.)

lied to nickel-glance, and probably identical with it.

2.)—Solid bodies which do not exhibit any crystalline or
inutest particles, are said to be *amorphous* (*α*, privative,
and other forms of silica, also glass, obsidian, pumice
minous substances, and numerous precipitates. Such
racture, never exhibiting a granulated appearance on the
rticular planes of cleavage, such as are found in crystals,
f force to separate them in all directions: they also
ctions, and never exhibit double refraction, excepting
ht into a forced state. In short, the essential character
uniformity of structure in every direction, each particle
se which surround it, the character of a fluid without
sed or organised* bodies, the molecular forces act with
or axes, thereby determining an arrangement of the
, and causing the body to exhibit different degrees of
, refracting power, and conducting power for heat and
. It must not be assumed that a body is amorphous
gular shape in the mass: marble and loaf-sugar have
ey consist of aggregates of minute crystals, and when
l, but a granular fracture.

means peculiar to certain substances, a great number
ng both in the amorphous and in the crystalline state.
ly from fusion or solution, forms regular crystals, but
e into cold water, it solidifies in a soft, plastic, viscid
out into threads, and exhibiting no trace whatever
horus also assumes a regular crystalline form when
isulphide of carbon or from fusion, but when cast into
rms a waxy solid, having a conchoidal fracture; and
be described hereafter, it may be reduced to a perfectly
is crystalline in the diamond and in graphite; amor-
and the various other forms which it assumes when

---

used in contradistinction to *crystalline* alone; but its proper use
crystalline or organised: for organic structures exhibit many
s, properly so called, are destitute; thus wood, according to the
hree distinct axes of cleavage, permeability, elasticity, and con-

separated from organic bodies by imperfect combustion. Boron and silicon exhibit similar varieties. Arsenious acid, as it collects in the chimneys of furnaces in which arsenical ores are roasted, is a glassy amorphous mass; but by dissolving it in hot water or hydrochloric acid, and leaving the solution to cool, it is obtained in the crystalline form (see ARSENIC). Native sulphide of antimony, which is crystalline, may be rendered amorphous by melting it in a glass tube and plunging the tube into ice-cold water: and by melting it again and cooling slowly, the crystalline structure may be restored. Similar transformations may be effected with native sulphide of mercury, also with the minerals Vesuvian and Axinite, and certain varieties of garnet. Glass, which is perhaps the most characteristic of amorphous bodies, may be devitrified by keeping it for some time in the soft state at a high temperature: it then acquires a crystalline structure and becomes nearly opaque, forming the substance called Reaumur's porcelain. Generally speaking, rapid cooling from fusion is favourable to the assumption of the amorphous structure, while crystallisation is promoted by slow cooling, the particles then having time to arrange themselves in a definite manner. It is also true to a great extent that bodies which pass at once from the perfectly fluid to the solid state, — water, for instance, — crystallise on solidifying, whereas those which pass through the viscous form, like glass, solidify in the amorphous state; to this, however there are some striking exceptions: thus sugar, the solution of which is extremely viscid when concentrated, solidifies by slow evaporation in crystals of great size and regularity.

The passage from the amorphous to the crystalline state sometimes takes place spontaneously, the body all the while remaining solid. Vitreous arsenious acid, which, when recently prepared, is perfectly transparent, becomes turbid when left to itself for a few months, and subsequently white and opaque. Sugar which has been melted in the form of barley-sugar is in the vitreous state, but after a while acquires a crystalline structure and becomes opaque. These phenomena show that the molecules of bodies, even in the solid state, possess a certain freedom of motion.

The change from the amorphous to the crystalline condition, or the contrary, is generally accompanied by an alteration of other physical properties. Bodies are for the most part denser and less soluble in the crystalline than in the amorphous state, and have less specific heat. Vesuvian, which crystallises in square prisms of specific gravity about 3·4, and garnet, which occurs in rhombic dodecahedrons of specific gravity 3·63, both form by fusion and subsequent cooling, transparent glasses whose specific gravity is about 2·95, so that, in passing from the crystalline to the amorphous state, garnet suffers an expansion of about $\frac{1}{5}$ and vesuvian of $\frac{1}{7}$. The glass also dissolves readily in hydrochloric acid, whereas the crystallised minerals are quite insoluble. Many other crystalline siliceous minerals not soluble in acids become so by fusion, probably from the same causes. Quartz, which is crystallised silica, is much harder and denser than opal, which is the same chemical compound in the amorphous state. Quartz-powder dissolves but very slowly in boiling potash-ley and is quite insoluble in that liquid when cold, whereas pulverised opal is gradually dissolved at ordinary temperatures and in a few minutes at the boiling heat. A remarkable exception to the general rule is, however, presented by arsenious acid, which is both less dense and more soluble in the crystalline than in the vitreous state.

Another difference first observed by Graham is, that bodies have greater specific heat in the amorphous than in the crystalline state. Ordinary phosphate of sodium (PO^4Na^2H) solidifies from fusion in the vitreous state; the corresponding arsenate in the crystalline form: now the former in solidifying gives out perceptibly less heat in a given time than the latter, a greater portion of the latent heat of fusion appearing to be retained by it. Connected with this law is the remarkable phenomenon of incandescence which many bodies exhibit when their temperature is gradually raised. Hydrated oxide of chromium if heated merely to the point at which it parts with its water, remains nearly as soluble in acids as before, but if the heat be raised nearly to redness, the oxide suddenly becomes incandescent, and is afterwards found to be much denser and nearly insoluble in acids. Similar phenomena are exhibited by alumina and zirconia. Gadolinite (silicate of yttrium) which in its natural state exhibits a conchoidal fracture and obsidian-like appearance, becomes vividly incandescent when moderately heated, and is afterwards found to dissolve but very imperfectly in hydrochloric acid, although before ignition it is very easily soluble; its density increases at the same time, though its absolute weight remains unaltered. Vitreous arsenious acid also sometimes exhibits incandescence in passing from the amorphous to the crystalline state. When a solution of the vitreous acid in hot hydrochloric acid is left to cool in the dark, the formation of every crystal is accompanied by a flash of light; but a solution of the crystalline acid, under the same circumstances, exhibits no light whatever.

acid isomeric with salicylic acid, $C^7H^6O^3$, obtained in
of strong nitric acid upon those schist-oils which boil
c acid and a flocculent matter are formed at the same time.
ance, without odour, nearly insoluble in cold water, but
Its solution reddens litmus. Boiling alcohol and ether
ling deposit it in the form of a powder, having a scarcely
er. Saturated with ammonia, it exhibits the following
alcium, a white precipitate, which does not form when
stals on cooling. No precipitate with the chlorides of
, or mercury. A green precipitate with acetate of
copper; and white with acetate and nitrate of lead.
lxiv. 325.)

e resembling creosote, obtained from that portion of
200° and 280° C. The oil is shaken up several times
n mixed with $\frac{1}{15}$ or $\frac{1}{20}$ of its bulk of aqueous potash, and
ay. The lower watery layer of liquid is then separated
shaken up with dilute sulphuric acid, and the oil which
with a pipette, and gently heated with 10 or 20 times
ves the ampelin, leaving a small quantity of oil. On
a few drops of sulphuric acid to the aqueous solution,
in the form of an oil, having a slight brownish tint.
0 times its volume of water, and is separated from the
uric or nitric acid, even when very dilute. Potash, soda,
solution slightly turbid at the first instant, but it recovers
Carbonate of ammonium renders it permanently turbid.
of ammonium added to a solution of ampelin in caustic
m separates the ampelin, which is then not redissolved
lin dissolves in alcohol, and in all proportions in ether.
It is decomposed by distillation, yielding water, a light
ic acid attacks it strongly, producing oxalic acid, and
(Laurent, Ann. Ch. Phys. [2] lxiv. 321.)

HIBOLITE. (See HORNBLENDE.)

ame applied by Berzelius to salts which, according to
o *oxides*, *sulphides*, *selenides*, or *tellurides*, *e. g.* sulphate
enate of potassium, $3K^2S.As^2S^5$; sulphantimonate of
ch salts containing three ultimate elements—in contra-
ts, namely, the chlorides, bromides, iodides, &c., which
rst order, containing only two elements, such as chloride
er, AgI, &c. It is evident that the so-called amphid
to the *water-type*, *e. g.* nitrate of copper, $CuO.N^2O^5 =$
f potassium, $3K^2S.As^2S^5 = S^3\left\{\begin{matrix}(AsS)'''\\ K^3\end{matrix}\right.$, whereas the
e type HH or HCl.

CITE.

DIDRIMITE.—**AMPHODELITE.** See ANORTHITE.

${}^{0}H^{26}O^{12}$.—Produced by the metamorphosis of amygdalin
. Amygdalin dissolves in cold baryta-water without
the mixture, ammonia is disengaged. The ebullition is
of ammonia ceases altogether; a current of carbonic
he liquid, to precipitate the excess of baryta; and the
he barium-salt by cautious precipitation with sulphuric
quid, which dries up to a gummy mass,—insoluble in
ng, and insoluble in ether. Boiled with a mixture of
uric acid, it yields formic and carbonic acids and hydride
well defined; they are more or less soluble in water.
h. Pharm., lxiv. 185.)

ined, according to Wöhler, by dropping a mixture of
drochloric acid gas. (Wöhler, Ann. Ch. Pharm. lxvi.

${}^{11} + 3H^2O$.—A crystalline principle existing in bitter-
rasus lauro-cerasus, and many other plants, which by
cid. The bitter-almond oil and hydrocyanic acid do
e plants, but are the result of the decomposition of
f emulsin, a nitrogenised fermentable principle existing

To prepare amygdalin,—the oil is expressed from the paste of bitter-almonds, and the residual mass extracted with boiling alcohol. This alcoholic solution is rendered turbid by the presence of globules of oil, which are allowed to collect and separated by decantation; it is then evaporated to half its original volume, and the amygdalin separated by the addition of ether, in which it is insoluble. The precipitated amygdalin is pressed between folds of bibulous paper, washed with ether, and finally crystallised from concentrated boiling alcohol. (Liebig and Wöhler.)

Amygdalin crystallises in white scales having a pearly lustre, insoluble in ether, but very soluble in water, from which it crystallises in thin transparent prisms containing 3 atoms of water of crystallisation. Its aqueous solution has a slightly bitter taste. It deflects the plane of polarisation of a ray of light to the left: [*a*] = 35·51. The change which amygdalin undergoes by the action of emulsin (and other albuminous vegetable principles), is expressed by the following equation:

$$\underset{\text{Amygdalin.}}{C^{20}H^{27}NO^{11}} + 2H^2O = \underset{\text{Hydride of benzoyl.}}{C^7H^6O} + \underset{\text{Hydrocyanic acid.}}{CNH} + \underset{\text{Glucose.}}{2C^6H^{12}O^6}$$

By distillation with nitric acid, or other oxidising agents, it is resolved into ammonia, hydride of benzoyl, benzoic, formic, and carbonic acids. Caustic alkalis convert it into amygdalic acid.

It is a neutral body, forming compounds neither with acids nor with alkalis.

AMYL, C^5H^{11}, or $C^{10}H^{22}$. (Gm. xi. pp. 1—83; Gerh. ii. pp. 675—708).—The fifth term of the series of alcohol-radicles, C^nH^{2n+1}. The alcohol in an impure state (potato-fusel oil), appears to have been first noticed by Scheele; and has been investigated, together with its derivatives, by Pelletan (J. Chim. med. i. 76, also Ann Ch. Phys. [2] xxx. 200), Dumas (Ann. Ch. Phys. [2] lvi. 314; Dumas and Stas Ann. Ch. Phys. [2] lxxiii. 128); Cahours (Ann. Ch. Phys. [2] lxx. 81, lxv. 193) and Balard, Ann. Ch. Phys. [3] xii. 294). The radicle itself was isolated by Frankland in 1849. (Chem. Soc. Qu. J. iii. 307; Ann. Ch. Pharm. lxxiv. 41.)

Amyl in the free state, $C^{10}H^{22} = C^5H^{11}.C^5H^{11}$, is prepared by the action of zinc amalgam upon iodide of amyl, the reaction being completed by the addition of potassium (Frankland).—2. By the action of sodium upon iodide of amyl (Wurtz).—3. By the electrolysis of caproate of potassium (Brazier and Gossleth).—4. By the destructive distillation of certain kinds of coal (Greville Williams).

(1.) Pasty zinc-amalgam is brought into the copper cylinder used in the preparation of zinc-ethyl (see ETHYL): the cylinder is then half filled with granulated zinc and iodide of amyl is added. After gently warming to expel the air, the cylinder is closed and heated for several hours at about 170° C. After cooling, it is opened and potassium is added (about $\frac{1}{20}$th by weight of the iodide of amyl employed). The cylinder is again closed and heated for an hour at the same temperature. To obtain the amyl the cylinder is heated in a water-bath at 80° C., whereupon amylene and hydride of amyl pass over. On applying the heat of a naked flame, amyl distils over, and may be purified by one rectification. (Frankland.)

(2.) Iodide of amyl is warmed with sodium, and distilled; the product again distilled from sodium and rectified, the portion which passes over at 158° C. being collected apart. (Wurtz, Ann. Ch. Phys. [3] xliv, 275.)

(3.) A concentrated solution of caproate of potassium is submitted to the electrolytic action of six zinc-carbon elements, the platinum poles being separated by a porou diaphragm. Amyl collects upon the surface of the liquid surrounding the negative pole: it is distilled from alcoholic caustic potash and washed with water. (Brazie and Gossleth, Chem. Soc. Qu. J. iii. 221.)

(4.) Bog-head naphtha is submitted to fractional rectification, the portion boiling b tween 154°—169° C. being collected apart, and the product thus obtained is submitte to the action of fuming nitric acid, the action of the acid being checked by cold. Th mixture on standing separates into two layers, the upper of which is again shake with nitric acid. The product which has remained unacted upon is washed wit caustic soda and water successively, dried with solid caustic potash, and distilled ove sodium. The resulting liquid is again rectified at 157°—160° C. (C. Grevill Williams, Phil. Trans. 1857, 447.)

Amyl is a transparent colourless liquid, of agreeable smell and burning taste Specific gravity, 0·77 at 11° C.—Boiling-point 155°—159° C. Vapour-density 4·90. I is miscible with alcohol, immiscible with water. Amyl is not acted upon by fuming su phuric acid; it is slowly attacked by nitric and nitro-sulphuric acids, and decompose after long digestion with pentachloride of phosphorus.

BROMIDE OF AMYL.—Prepared by the action of bromine and phosphorus upo amylic alcohol (Cahours, Ann. Ch. Phys. [2] lxx. 98). In three flasks are placed respe

l, 2⅓ pts. of bromine, and 1 pt. of phosphorus. A little
the amylic alcohol, and the latter is poured upon and
to decoloration. It is then poured into its own flask,
dded. The process is repeated, and the final product is
rectified.

sparent colourless liquid, heavier than water. It has an
aste. It is soluble in alcohol, insoluble in water. De-
holic caustic potash.

^{11}Cl.—Obtained by the action of strong hydrochloric acid
Ann. Ch. Phys. [3] xii. 294); also by the action of penta-
mylic alcohol. (Cahours.)

cohol is heated in a retort to 110° C., a rapid current of
ed through the tubulus into the amylic alcohol; the
med distils over. When the retort is nearly empty the
the same process repeated (Guthrie). The product is
chloric acid, in which amylic alcohol is soluble, chloride
water.

led with its own weight of pentachloride of phosphorus,

less, transparent, neutral liquid, of agreeable odour. It
sity, 3·8. Burns with a luminous flame bordered with

of amyl, giving rise to substitution-products, which go

CYANIDES.

MYL-ALCOHOL, $C^5H^{12}O = \left.\begin{matrix}C^5H^{11}\\H\end{matrix}\right\}O$ [or $C^{10}H^{12}O$· =
ydrogen. Hydrate of Amyl. Hydrate of Pentyl. Hy-
-oil.—This alcohol seems invariably to accompany ethylic
hen the latter is formed by fermentation. The conditions
it seems, however, to occur in largest quantity in those
aline during fermentation. In the distillation of vege-
fermented, the latter portions of the distillate contain
ylic and amylic alcohols, besides the acids and aldehydes
y higher fatty acids and aldehydes. To obtain the pure
product, it is shaken several times with hot milk of lime,
of calcium, and rectified at 132° C.

rent colourless liquid having a peculiar odour (the peaty
resence in small quantities), which causes coughing, and
h a white smoky flame. Solidifies at about − 22° C.
9° C. Boiling-point 132° C. Vapour-density 3·147.
nd ether, nearly insoluble in water. It dissolves small
sphorus.

mpt. rend. xli. 296), ordinary amylic alcohol is a mixture
ical in chemical composition and vapour-density, but
rties, one of them turning the plane of polarisation of a
e other is opticially inactive. A difference of solubility in
n the mixed alcohols, furnishes the means of their separa-
e of barium is 2½ times more soluble in water than the
The optical rotatory power of amylic alcohol varies, on
mixture of these two modifications. This difference in
d to be traceable in some other of their derivatives, *e. g.*
ctive cyanide of amyl, rotates the plane of polarisation.

ohol.—1. By *heat.* The vapour of amyl-alcohol passed
to dull redness, is resolved into tritylene (propylene)
rbons. (Reynolds.)

cohol is difficult to set on fire, and burns with a white
th the air at ordinary temperatures, it is very slowly
acid reaction. The oxidation is greatly accelerated by
ck, the amyl-alcohol being then converted into valeric

$$^{12}O + O^2 = C^5H^{10}O^2 + H^2O.$$

mixture of sulphuric acid and peroxide of manganese or
lds valeric aldehyde, valeric acid, and valerate of amyl.
with nitrite of amyl and hydrocyanic acid, are formed
Amyl-alcohol is also converted into valeric acid by heat-

ing it to 220° C. with a mixture of lime and hydrate of potassium, hydrogen gas being evolved:

$$\underset{\text{Amyl-alcohol.}}{\mathrm{C^5H^{12}O}} + \mathrm{KHO} = \underset{\text{Valerate of potassium.}}{\mathrm{C^5H^9KO^2}} + \mathrm{4H.}$$

3. By *sulphuric acid.*—Amyl-alcohol mixes readily with strong sulphuric acid, forming a red liquid, which contains amylsulphuric acid, $\mathrm{SO^4.C^5H^{11}.H}$, as well as free sulphuric acid. On distilling the mixture, the amyl-alcohol is dehydrated, and amylene, $\mathrm{C^5H^{10}}$ passes over, together with the polymeric compounds, $\mathrm{C^{10}H^{20}}$ and $\mathrm{C^{20}H^{40}}$, and perhaps also amylic ether, $\mathrm{(C^5H^{11})^2O}$; at the same time, however, a portion of the alcohol is oxidised and converted into valeric aldehyde and valeric acid, sulphurous acid being evolved and a black pitchy mass remaining in the retort.

4. With *phosphoric acid*, amyl-alcohol yields amyl-phosphoric acid, $\mathrm{PO^4.C^5H^{11}.H^2}$.—Distilled with phosphoric anhydride, it is converted into amylene and its multiples.

5. *Trichloride of phosphorus* converts amyl-alcohol into phosphite of amyl, amyl-phosphorous acid, chloride of amyl, and hydrochloric acid:

$$\mathrm{3(C^5H^{11}.H.O)} + \mathrm{PCl^3} = \underset{\text{Phosphite of amyl.}}{\mathrm{PO^3.(C^5H^{11})^2.H}} + \mathrm{C^5H^{11}Cl} + \mathrm{2HCl.}$$

$$\text{and}\quad \mathrm{3(C^5H^{11}.H.O)} + \mathrm{PCl^3} = \underset{\text{Amylphosphorous acid.}}{\mathrm{PO^3.C^5H^{11}.H^2}} + \mathrm{2C^5H^{11}Cl} + \mathrm{HCl.}$$

6. With *pentachloride of phosphorus*, amyl-alcohol forms chloride of amyl, hydrochloric acid, and chlorophosphoric acid, or, when the amyl-alcohol is in excess, diamylphosphoric acid:

$$\mathrm{C^5H^{11}.H.O} + \mathrm{PCl^5} = \mathrm{C^5H^{11}Cl} + \mathrm{HCl} + \underset{\text{Chlorophosphoric acid.}}{\mathrm{POCl^3}}$$

$$\text{and}\ \mathrm{9(C^5H^{11}.H.O)} + \mathrm{2PCl^5} = \mathrm{5C^5H^{11}Cl} + \mathrm{5HCl} + \underset{\text{Diamylphosphoric acid.}}{\mathrm{2[PO^4.(C^5H^{11})^2.H]}} + \mathrm{H^2O.}$$

7. *Chlorine-gas* is absorbed in large quantity by amyl-alcohol and forms chloramylal, a compound homologous with chloral.—8. Amyl-alcohol absorbs *hydrochloric acid gas* and mixes with the concentrated aqueous acid; on heating the mixture chloride of amyl is formed.—9. It dissolves, with the aid of heat, in a concentrated aqueous solution of *chloride of zinc*, forming a liquid which boils at 130°C., and yields a distillate of amylene and its multiples.—10. Distilled with *phosphorus* and *bromine* or *iodine*, it yields bromide or iodide of amyl.—11. Distilled with *fluoride of boron*, or *fluoride of silicon*. it yields amylene and its multiples, but little or no oxide of amyl.—11. *Phosgene gas* is abundantly absorbed by amyl-alcohol, forming chloroformate of amyl, and the liquid when distilled yields carbonate of amyl (Medlock) [*with evolution of phosgene* (?)]

$$\mathrm{C^5H^{11}.H.O} + \underset{\text{Phosgene.}}{\mathrm{COCl^2}} = \underset{\text{Chloroformate of amyl.}}{\mathrm{CClO^2.C^5H^{11}}} + \mathrm{HCl.}$$

$$\text{and}\quad \mathrm{2(CClO^2.C^5H^{11})} = \underset{\text{Carbonate of amyl.}}{\mathrm{CO^3.(C^5H^{11})^2}} + \mathrm{COCl^2}\quad [?]$$

Carbonate of amyl is also obtained by adding water to the solution of phosgene in amyl-alcohol (Medlock):

$$\mathrm{2(CClO^2.C^5H^{11})} + \mathrm{H^2O} = \mathrm{CO^3.(C^5H^{11})^2} + \mathrm{2HCl} + \mathrm{CO^2.}$$

21. *Disulphide of carbon*, in presence of *potash*, converts amyl-alcohol into amylsulphocarbonic or amylxanthic acid (p. 206).—13. *Chloride of cyanogen* is rapidly absorbed by amyl-alcohol, and forms products similar to those which it yields with ethyl-alcohol.

$$\underset{\text{Amyl-alcohol.}}{\mathrm{C^5H^{12}O}} + \mathrm{CNCl} + \mathrm{H^2O} = \underset{\text{Amyl-urethane.}}{\mathrm{C^6H^{13}NO^2}} + \mathrm{HCl.}$$

14. Potassium (and sodium) decomposes amyl-alcohol in the same manner as ethyl alcohol, forming amylate of potassium, $\mathrm{C^5H^{11}KO}$ with evolution of hydrogen.

Amyl-alcohol combines with a few metallic chlorides in the same manner as ethyl-alcohol. With *chloride of calcium* and *dichloride of tin*, it forms crystalline compounds which are decomposed by water. It dissolves in caustic potash and soda.

HYDRIDE OF AMYL, $\mathrm{C^5H^{11}.H}$.—Iodide of amyl is heated with zinc and its own volume of water for a few hours to 142° C. in a copper cylinder (see zinc-ethyl), and the contents are distilled from a water bath at 60°. The distillate consists principally of amylene and hydride of amyl. The mixture is left for 24 hours in contact with

ectified from a water-bath at 35°. The distillate is
re and treated with a mixture of anhydrous and fuming
the amylene. Lastly, the hydride of amyl is distilled
nd, Ann. Ch. Pharm. lxxiv. 41). Colourless transparent
our. Specific gravity 0·638, at 14° C. Boiling-point
2.

.—Prepared by the action of iodine and phosphorus upon
nn. Ch. Phys. [2] lxx. 81). Four parts of iodine are
ss of phosphorus in another. Seven parts of moist amylic
iodine, the liquid shaken till opacity is produced, then
and digested till the colour is removed—again poured
till all the iodine is exhausted. The nearly colourless
hed with slightly alkaline water, dried over chloride of
atter portions are the purest.
ess transparent liquid of faint odour and pungent taste.
C. Boiling-point 146°. Vapour-density 6·675. It turns

O = $(C^5H^{11})^2O$ [or *$C^{10}H^{11}O$*]. — *Amylic ether. Amylate*
e action of sulphuric acid on amyl-alcohol. Strong
150° C. in a retort. and amyl-alcohol allowed to enter
the distillate is then shaken with carbonate of sodium,
y the action of amylate of potassium on iodide of amyl.
gested in a retort connected with an inverted con-
uantity of iodide of amyl, and the product is distilled and
tillation of amylsulphate of calcium (Kekulé). Oxide
. It is colourless and of agreeable odour.

thyl, $C^7H^{16}O = C^2H^5.C^5H^{11}.O$. *Amylate of Ethyl, Ethylate*
Prepared by the action of amylate of potassium upon
f amyl upon ethylate of potassium. (Williamson, Chem.
.) A known weight of potassium is dissolved in absolute
; iodide of amyl is added in sufficient quantity for there
of iodine for every at. of potassium in the ethylate of
nnected with an inverted condenser; and the contents
After distillation, water is added, and the liquid which
ectified.—(2.) Iodide of ethyl is added to a hot solution
digested &c., as in 1 (Guthrie). Amylate of ethyl is
uid of agreeable odour, similar to that of sage. It is
-point 112° C. Vapour-density 4·04.

ethylate of Amyl, $C^6H^{14}O = CH^3.C^5H^{11}.O$, is prepared in
late of ethyl (Williamson). Boils at 92° C. Vapour-

$^5H^{11}KO$. — On bringing freshly cut potassium into dry
n is dissolved and hydrogen is evolved. To obtain this
action is aided by heat until the mass becomes viscid.
have remained unacted upon are removed, and the pro-
ab, and allowed to solidify. It is then strongly pressed
us paper to remove the unaltered amylic alcohol.
crystalline white body, soapy to the touch, and alkaline
the alcohols. By water it is instantly converted into amylic
ium.

aO. Closely resembles amylate of potassium.

Protosulphide of Amyl. $(C^5H^{11})^2S$ or $C^{10}H^{22}S$.—
ylsulphate and monosulphide of potassium are intimately
n and evaporation) and distilled (Balard, Ann. Ch. Phys.
uid of offensive odour. Boiling-point 216° C. Vapour-

$H^{11}S$.—Obtained by distilling together amylsulphate and
Henry, Ann. Ch. Phys. [3] xxv. 246). Amber-coloured
°. Specific gravity ·918 at 18° C.

Hydrogen: Amyl-mercaptan, $C^5H^{11}.H.S$ [or *$C^{10}H^{11}S.HS$.*]
ustic potash with sulphuretted hydrogen, adding the
ate of potassium (prepared by mixing equal weights of
acid, neutralising with carbonate of potassium and filter-
pacious retort in a chloride of calcium bath. The oily
washed, dried, and rectified (Kreutzsch, J. pr. Chem.
of intolerable odour. It is soluble in alcohol and ether,

but insoluble in water. Specific gravity 0·845 at 0° C. Boiling-point about 120° C. Vapour-density 3·631. It combines with metallic oxides.

Amylmercaptide of mercury is obtained as a colourless liquid on bringing amylmercaptan in contact with mercuric oxide. The mixture solidifies to a solid mass on cooling. The compound is insoluble in water, but soluble in boiling alcohol. The other amylmercaptides are not distinctly known.

Sulphide of Carbonyl, Amyl, and Hydrogen. Amylsulphocarbonic acid. Amylxanthic acid. $C^6H^{12}S^2O = \left.\begin{matrix}(CO)'' \\ C^5H^{11}.H\end{matrix}\right\} S$. — The free acid is prepared from the potassium-salt by treating the aqueous solution of the latter with dilute hydrochloric acid (Balard, Ann. Ch. Phys. [3] xii. 307). Light yellow oily liquid, of penetrating odour, heavier than water, acid to test paper. It is quickly decomposed by water.

Amylxanthate of potassium, $C^6H^{11}.K.S^2O$.—A cold saturated solution of hydrate of potassium in amylic alcohol, is treated with bisulphide of carbon until the alkaline reaction has disappeared, and the yellow crystals of the potassium-salt which separate out on cooling, are washed with ether, and dried between blotting paper.

The ethyl and methyl salts of amylxanthic acid, are formed by digesting equivalent quantities of ethylsulphate or methylsulphate of potassium, with amylsulphocarbonate of potassium. They are oily liquids lighter than water. (Johnson, Chem. Soc. Qu. J. v. 142.)

Dioxysulphocarbonate of Amyl, $C^6H^{11}S^2O$. — The compound so-called, which contains 1 at. hydrogen less than amylxanthic acid, is produced by the action of iodine on amylxanthate of potassium. It is an oily liquid which boils at 187° C, undergoing decomposition at the same time, and yielding among other products amylxanthate of amyl, $CS^2O.(C^5H^{11})^2$. Digested with aqueous ammonia, it yields *amylxanthate of ammonium*, and *xanthamylamide* or *sulphocarbamate of amyl*, $\left.\begin{matrix}(CS)''H^2 \\ C^5H^{11}\end{matrix}\right\}\begin{matrix}N \\ O\end{matrix}$

$$\underbrace{2C^6H^{11}S^2O}_{\text{Dioxysulpho-carbonate of amyl.}} + 2NH^3 = \underbrace{CS^2O.C^5H^{11}.NH^4}_{\text{Amylxanthate of ammonium.}} + \underbrace{C^6H^{13}NSO}_{\text{Xanthamylamide.}} + S.$$

The last mentioned compound, *xanthamylamide*, is a yellow neutral oil, which boils at 184° C. but not without decomposition, being resolved by distillation into amylmercaptan and cyanuric acid:

$$3C^6H^{13}NSO = 3C^5H^{12}S + C^3N^3H^3O^3.$$

Heated on platinum foil, it burns with a yellow luminous flame, giving off white vapours. Boiled with hydrate of barium, it is resolved into amyl-alcohol and sulphocyanide of barium:

$$2C^6H^{13}NSO + Ba''H^2O^2 = 2C^5H^{12}O + (CNS)^2Ba'' + 2H^2O;$$

similarly with potash. It is decomposed by chlorine and by nitric acid.

Xanthamylamide is insoluble in water, but dissolves readily in alcohol and ether. It unites with chloride of mercury, forming the compound $C^6H^{13}NSO.4HgCl$, which crystallises in white feathery crystals. With dichloride of platinum dissolved in water, it forms a yellow precipitate. (M. W. Johnson, Chem Soc. Qu. J. v. 142.)

Amysulphocarbamic acid, $C^6H^{13}NS^2$ (see next page).

TELLURIDE OF AMYL, or TELLURAMYL, $(C^5H^{11})^2.Te$. has been obtained in an impure state by distilling telluride of potassium with amylsulphate of calcium. It is a liquid having a strong disagreeable odour, and boiling at about 198° C. but decomposing at the same time, and depositing tellurium in small shining prisms. By exposure to the air it is converted into a white mass. The nitrate of telluramyl is a colourless heavy oil, obtained by heating telluramyl with moderately strong nitric acid. Treated with the bromide, chloride, or iodide of hydrogen or sodium, it yields the corresponding compounds of telluramyl in the form of viscid heavy oils. The chloride treated with oxide of silver, yields *oxide of telluramyl* in the form of an oily liquid soluble in water, and so strongly alkaline that it separates ammonia from sal-ammoniac. It forms a crystalline salt with sulphuric acid. (Wöhler and Dean, Ann. Ch. Pharm. xcvii. 1.)—F. G.

AMYLAMINES:

AMYLAMINE, $C^5H^{13}N = C^5H^{11}.H^2.N$. *Amylammonia, Amylia.*—This organic base is formed: (1.) By heating cyanate or cyanurate of amyl with caustic potash (Wurtz, Ann. Ch. Phys. [3] xxx. 447):

$$\underbrace{CNO.C^5H^{11}}_{\text{Cyanate of amyl.}} + \underbrace{2KHO}_{\text{Hydrate of potassium.}} = \underbrace{C^5H^{13}N}_{\text{Amylamine.}} + \underbrace{CO^3K^2}_{\text{Carbonate of potassium}}.$$

tion of animal substances (Anderson).—(3.) By heat-
with alcoholic ammonia to 250° C. (Berthelot).—(4.)
ine, carbonic anhydride being at the same time evolved
ı. cii. 221):

$$\underbrace{H^{13}NO^2}_{\text{eucine.}} = \underbrace{C^5H^{13}N}_{\text{Amylamine.}} + CO^2$$

olution of horn in strong caustic potash, leucine being
composed as above (Schwanert).—(5.) By the action
etrylamine being also found among the products. (Gr.
310.)
cyanurate of amyl (obtained by distilling cyanate of
of potassium) is distilled with strong caustic potash;
ith hydrochloric acid, evaporated and recrystallised;
mine decomposed by distillation from lime and rectified
urless liquid. Specific gravity 0·75 at 18° C. Boiling-
ecipitates most metallic oxides which are precipitable
mina.
rmed as a crystalline solid, when its base is exposed to
Hydrobromate of amylamine, $C^5H^{13}N.HBr$, or *bromide*
ned by adding hydrobromic acid to the base.—*Hydro-*
N.HCl or *chloride of amylium*, $C^5H^{14}NCl$, forms with
salt, $C^5H^{14}NCl.PtCl^2$, which is soluble in boiling water.
ylium, $C^{11}H^{26}N^2S^2 = \left.\begin{matrix}(CS)''.H.C^5H^{11}\\ N(H^3.C^5H^{11})\end{matrix}\right\}\begin{matrix}N\\ S\end{matrix}$, is produced
amylamine with 1 molecule of bisulphide of carbon:
²). The mixture of the two substances becomes warm,
npound in white shining scales, insoluble in water and
lcohol. At 100° C. it decomposes after a while, giving
Treated with hydrochloric acid, it yields chloride of
mic acid $\left.\begin{matrix}(CS)''.H.C^5H^{11}\\ H\end{matrix}\right\}\begin{matrix}N\\ S\end{matrix}$, which is an oily body,
d potash; mixed with amylamine, it reproduces the
ann, Chem. Soc. Qu. J. xiii. 60.)

N.—When amylamine is heated to 100° C. with bromide
rs, and the solid hydrobromate of diamylamine is formed.
lation of the bromide with caustic potash (Hofmann,
Slightly soluble in water. Boiling-point about 170°.
difficultly soluble in cold water, more readily in hot

N, is obtained by heating diamylamine with bromide of
ned bromide of triamylium with caustic potash (Hof-
ose of its salts are similar to those of diamylamine. It

Tetramylammonium.—Ammonium in which the whole
amyl. Not known in the separate state, but obtained
odide of amyl on triamylamine, the mixture solidifying,
ing, into an unctuous crystalline mass. The iodide of
but very slowly, by heating iodide of amyl in a sealed
nmonia. This salt, $N(C^5H^{11})^4.I$, dissolves sparingly in
itter liquid, from which it is precipitated in the crystal-
with oxide of silver, it yields a very bitter alkaline solu-
ium:

$$I + AgHO = AgI + \left.\begin{matrix}N(C^5H^{11})^4\\ H\end{matrix}\right\}O.$$

otash, or concentrating it strongly by evaporation, the
to the surface in the form of an oily layer, which
ately concentrated solution of the base left to evaporate
carbonic acid, deposits the hydrate in definite crystals
containing several atoms of water of crystallisation.
melt in their water of crystallisation, and ultimately
he form of a semi-solid transparent mass. At higher
completely decomposed, giving off water, triamylamine,
robably amylene:

$$\underbrace{N(C^5H^{11})^4H.O}_{\text{Hydrate of tetramylium.}} = H^2O + \underbrace{N(C^5H^{11})^3}_{\text{Triamyl-amine.}} + \underbrace{C^5H^{10}}_{\text{Amylene.}}$$

Hydrate of tetramylium dissolves readily in acids, forming solutions which yiel crystalline salts by evaporation. The sulphate crystallises in long, capillary threads the nitrate in needles, the oxalate in large deliquescent plates, the chloride in lamina with palm-like ramifications; the chloroplatinate, $(C^4H^{11})^4NCl.PtCl^2$, in beautifu orange-yellow needles. (Hofmann, Chem. Soc. Qu. J. iv. 316.)—F. G.

(For the *Amyl-phosphines*, *Arsines*, and *Stibines*, see PHOSPHORUS, ARSENIC, an ANTIMONY.)

AMYLENE. C^5H^{10}, or $C^{10}H^{10}$.—This hydrocarbon, a homologue of ethylene o olefiant gas, and the fifth term of the series, C^nH^{2n}, is produced by the dehydration of amylic alcohol by sulphuric acid, phosphoric anhydride, or chloride of zinc, also b the dry distillation of amyl-sulphate of calcium (Kekulé). To prepare it, a concentrated aqueous solution of chloride of zinc is heated to 130° C., with an equal volume of amylic alcohol: and the product is distilled from a water-bath over caustic potash and repeatedly rectified (Balard, Ann. Ch. Phys. [3] xii. 320). It is a transparent colourless, very thin liquid, having a faint but offensive odour. Boils at 39° C (Balard); at 35° (Frankland); at 42° (Kekulé). Vapour-density, 2·68 (Balard) 2·386 (Frankland), 2·43 (Kekulé); (by calculation, for 2 vol. = 2·4265). The vapour is rapidly and completely absorbed by sulphuric anhydride and pentachloride of antimony (Frankland). It possesses anæsthetic properties, and has been trie as a substitute for chloroform, but has been found to be very dangerous, having i more than one instance led to fatal results.

Amylene is diatomic, like ethylene, uniting with 2 at. Br, NO^2, HO, &c., and with 1 at. O, S, &c.

ACETATE OF AMYLENE, $C^9H^{16}O^4 = \left.\begin{matrix}(C^5H^{10})''\\(C^2H^3O)^2\end{matrix}\right\}O^2$, is produced by heating the bromide $C^5H^{10}Br^2$, with a mixture of acetate of silver mixed with glacial acetic acid:

$$C^5H^{10}Br^2 + 2(C^2H^3O.Ag.O) = 2AgBr + \left.\begin{matrix}C^5H^{10}\\(C^2H^3O)^2\end{matrix}\right\}O^2.$$

It is a colourless neutral liquid, insoluble in water, boiling above 200° C. and easil decomposed by alkalis into acetic acid and amylene-glycol. (Wurtz, Ann. Ch. Phy [3] lv. 458.)

BROMIDE OF AMYLENE, $C^5H^{10}Br^2$, is produced by passing bromine-vapour into amylene. Heated in a sealed tube with alcoholic ammonia, it forms bromide of ammonium, and *bromamylene*, C^5H^9Br.—By treating amylene with a larger quantity o bromine, another compound is formed, containing $C^5H^9Br^3$, probably *dibromide o bromamylene*, $C^5H^9Br.Br^2$. This compound, treated with alcoholic potash, yields *di bromamylene*, $C^5H^8Br^2$. (Cahours, Ann. Ch. Phys. [3] xxxviii. 90.)

HYDRATE OF AMYLENE, or AMYLENE-GLYCOL, $C^5H^{12}O^2 = \left.\begin{matrix}(C^5H^{10})''\\H^2\end{matrix}\right\}O^2$.—Prepare by distilling acetate of amylene with dry pulverised hydrate of potassium, and purifie by a second distillation in the same manner, and subsequent rectification *per se:*

$$\left.\begin{matrix}C^5H^{10}\\(C^2H^3O)^2\end{matrix}\right\}O^2 + 2KHO = 2(C^2H^3KO^2) + \left.\begin{matrix}C^5H^{10}\\H^2\end{matrix}\right\}O^2.$$

It is a colourless, very syrupy liquid, having a bitter taste with aromatic after-tast When cooled with a mixture of solid carbonic acid and ether, it solidifies into a har transparent mass. It does not affect polarised light. Its specific gravity is 0·987 a 0° C. It boils at 177°, and distils without alteration. When pure it dissolves in wate in all proportions. The aqueous solution turns acid when exposed to the air in contac with platinum-black, yielding chiefly carbonic acid, with only a small quantity of fixed acid, apparently butylactic acid. When gently heated with nitric acid, it i rapidly oxidised, the chief product of the action being butylactic acid, C^4H^8O (Wurtz, *loc. cit.*)

Amylene-glycol, treated with hydrochloric acid, either gaseous or aqueous, is con verted, slowly at ordinary, more quickly at higher temperatures, into the *chlorhydri of amylene-glycol*, $C^5H^{10}.HO.Cl$. This compound cannot be isolated, but remains dis solved in the excess of acid and is decomposed by distillation. The acid solutio treated with potash yields oxide of amylene.

NITRYLIDE OF AMYLENE, $C^5H^{10}(NO^2)^2$. *Nitroxide of Amylene.*—Obtained b passing peroxide of nitrogen (nitryl, NO^2, prepared by heating anhydrous nitrate of lead into a flask containing amylene, and surrounded by a freezing mixture. The gas is i

ylene is gradually converted into a pasty mass of minute
fied by washing with cold alcohol, recrystallisation from
vacuo over sulphuric acid. It gave by analysis, 37·26
N; the formula requiring 37·09 C, 6·18 H, and 17·28 N.
obtained, though less advantageously, by passing vapour
to fuming nitric acid. It is remarkable as affording the
nbination of nitryl, (NO^2), with an organic radicle.
be, it decomposes at about 95° C., giving off nitrous an-
l, HNO^2, and leaving a heavy liquid apparently containing
quick lime, it gives off an aromatic body, probably con-
(Guthrie, Chem. Soc. Qu. J. xiii. 45, 129.)

$^9)''.O$, a volatile liqnid, isomeric with valeric aldehyde,
sant ethereal odour, and a rough taste. Specific gravity
0° C. Vapour-density by experiment 2·982, by calcula-
ns easily, with a yellow flame. It is insoluble in *water*,
nylene-glycol when heated with water in a sealed tube.
, and in a mixture of the two. It mixes with *acids*. It
tallisable nitric acid at a higher temperature, but the
h partial decomposition. (A. Bauer, Compt. rend.

D CHLORINE:

lene, $C^5H^{10}SCl^2$, or $C^{10}H^{10}S^2Cl^2$.—Protochloride of sul-
a flask surrounded with ice and an excess of amylene
xcess of amylene is evaporated off,—the residue digested
ed in ether, filtered, and evaporated. It is a non-volatile
our, insoluble in water, soluble in ether and alcohol.
C. Distilled with excess of alcoholic caustic potash, it
fusyl (C^5H^9S), and other products.
lene, $C^5H^{10}SCl$, or $C^{10}H^{10}S^2Cl$.—On treating disulphide
s of amylene, and evaporating the latter, a transparent
faint and nauseous odour is obtained, having the above
ure by digestion with water, solution in ether, filtration,
vity, 1·149 at 12° C. Soluble in ether, absolute alcohol,
thrie, Chem. Soc. Qu. J. xii. 112.)
e treated with chlorine, gives off hydrochloric acid, and
liquid, of specific gravity 1·406 at 16° C., miscible with
soluble in hot alcohol. This liquid gave by analysis
ely with the formula, $C^{10}H^7Cl^4S$, which may be that of
ne, $C^{10}(H^7Cl^3).SCl$, or that of *sulphide of tetrachloramyl*,
m. Soc. Qu. J. xiii. 43.)

D OXYGEN:

$^0H^{20}S^2O$.—Prepared by digesting the disulphochloride in
de of lead, till all the chlorine is combined, dissolving in
. Specific gravity, 1·054 at 13° C. Non-volatile, yellow,
in ether and alcohol, insoluble in water.
mylene, $C^{10}H^{20}S^2O.H^2O$.—Disulphochloride of amylene is
some hours, in a current of ammonia; the liquid is then
of ammonium formed, and heated for some hours in a
lcoholic ammonia; the excess of alcohol is driven off
treated with water; and the oil which is thereby pre-
. Yellow liquid of meaty odour. Somewhat soluble
ol and ether. Non-volatile. Specific gravity 1·049 at
u J. x. 120.)—F. G. and H. W.

$^{44}H^{64}O^7$. or $C^{44}H^{32}O^7$.—This acid is contained, together
the cashew nut (*Anacardium occidentale*). The pericarps
h dissolves out both the anacardic acid and the cardol;
he residue, after being washed with water to free it from
0 times its weight of alcohol. This alcoholic solution is
ated oxide of lead, which removes the anacardic acid in
salt. The lead-salt is suspended in water, and decom-
m, and from the solution of anacardate of ammonium,
he sulphide of lead by filtration, the anacardic acid is
lphuric acid. After repeated purification by solution in
d-salt, and decomposition of this salt by hydrosul-
d as a white crystalline mass, which melts at 26° C. It

has no smell, but its flavour is aromatic and burning. When heated to 200° C. it i decomposed, producing a colourless very fluid oil. It burns with a smoky flame, stain paper, and liquefies by prolonged contact with air, emitting an odour similar to tha of rancid fat. Alcohol and ether dissolve it readily, and these solutions redde litmus.

Some of its salts are crystalline, others amorphous. The silver-salt is a pulverulent white precipitate, soluble in alcohol, in presence of a free acid. It contains tw atoms of metal, $C^{44}H^{62}Ag^2O^7$. The lead-salt, obtained by mixing a boiling alcoholi solution of anacardic acid with an alcoholic solution of acetate of lead, is said to contain $C^{44}H^{60}Pb^2O^7$ or $C^{44}H^{60}Pb^2O^7$; if this formula be correct, the acid is tetrabasi [or dibasic, if the smaller atomic weights of carbon and oxygen are used]. The salt of ammonium, potassium, barium, calcium and iron, have been described, but they ar not very definite, and their formulæ have not been fixed. (Städeler, Ann. Ch Pharm. lxiii. 137.)

ANALCIME, $\left.\begin{matrix}Na^2\\Al^2\end{matrix}\right\}4SiO^3 + H^2O = Na^2O.SiO^2 + Al^2O^3.3SiO^2 + H^2O$ or $3NaO.2SiO^3 + 3(Al^2O^3.2SiO^3) + 2\,HO$.—A mineral belonging to the zeolite famil containing, according to H. Rose's analysis, 55·7 per cent. of silica, 13·5 soda, 23· alumina, and 8·3 water, which agrees very nearly with the preceding formula. I belongs to the regular system. Primary form a cube; it occurs also in leucite-octahedrons, and in cubes with the faces of the leucite-octahedron replacing the soli angles. Cleavage indistinct, parallel to the faces of the cube. Specific gravity from 2· to 2·2. Softer than felspar. In its purest form, it is colourless and transparent, bu sometimes white inclining to grey or flesh-colour. According to Brewster, it polarise light in a peculiar manner, indicating a grouping of the molecules very different fro that which is usually found in the regular system. Before the blowpipe, it loses wate and becomes milk-white; but when the heat is increased, it becomes clear again, an then melts quickly to a transparent glass. It is readily decomposed by hydrochlori acid, with separation of viscid silica; after ignition, however, the decomposition is le easy. Analcime occurs frequently in clefts and geodes in granite, trap-rocks and lava It is found on the Calton Hill, Edinburgh, at Talisker in the Isle of Sky, in Dumbartonshire, in the Ferroe Islands, in the Harz, and in Bohemia.

ANALYSIS—INORGANIC.

The object of chemical analysis is to ascertain the composition of any substanc whatever. The distinction usually made between organic and inorganic compounds has led to a corresponding division into organic and inorganic analysis: the latte being confined to the investigation of inorganic or mineral compounds. The method employed in this branch of analysis, are far more numerous and varied than thos hitherto devised for the analysis of organic compounds. Inorganic analysis is divide into qualitative and quantitative analysis. The former teaches us how to ascertain th elements of a substance with regard to their quality only, and how to separate them on from another: the latter establishes the methods of proceeding, by which we determin the relations of weight or volume, which these elements bear to one another. It i obvious that, before we can proceed to estimate the quantities of each element contained in a compound, we must know what are the elements that it contains: henc qualitative must always precede quantitative analysis.

Analysis is one of the most recent of the various branches of chemical science. Considerable progress had already been made in synthetical chemistry, in the preparatio of chemical compounds, &c. at a time when the foundations of analytical chemistr (in the sense at present attached to the term) had not even been laid. Less than century ago, when the properties and compounds of many elements were either entirel unknown or but imperfectly established, few problems were more difficult than that o inorganic analysis: the analyst had need of both penetration and caution in the highes degree, in order to discriminate between known and unknown substances. It is onl within a comparatively recent period, that the discovery of many new elements, an the more complete investigation of the reactions of those already known, have enable us to construct a systematic course of analysis, circumscribed within definite and we established rules.

Analytical chemistry, as we have already observed, aims at two objects, each close connected with the other:—1. To ascertain what are the elements contained in substances whose composition is unknown:—2. To determine the relative proportions o those elements whose existence has previously been qualitatively ascertained. In th earliest analytical researches, both these objects were pursued simultaneously. Hence in the very brief sketch of the history of analytical chemistry, which it is now ou purpose to give, it is not possible to trace the progress of each of these branches o analysis independently of the other. For this purpose it is more convenient to adop

until Lavoisier, with such triumphant success, employed the balance as a means c refuting old errors and of establishing new truths, that inquiries into the quantitativ composition of bodies came to be regarded as the only sure test and foundation fo chemical theory. Almost all the quantitative analyses by which any reliable know ledge of the constitution of substances has been obtained, are included in this perio and date within the last 60 or 70 years. The empirical results thus obtained, hav led to the discovery of the most important theoretical truths, *e.g.* the theory of ato and equivalents, the law of multiple proportions, &c., which in turn have been of in estimable value in controlling the results of analysis, and ensuring to them a degree accuracy which could never have been attained by merely empirical determinations.

Until a comparatively recent period, the only method of quantitative analysis wa that *by weight*. By this method, the substance to be estimated is either weighe directly, or in the form of some compound of known composition, from whose weig that of the substance to be estimated is readily calculated, the reagent by which th substance is separated being always employed *in excess*. More recently, another meth has been introduced, which depends upon the employment of only the exact quantit of the reagent which is necessary to produce the reaction desired; and upon the d termination of this quantity, not by weight, but by measure. This method, known the *Volumetric method of analysis* (see ANALYSIS VOLUMETRIC), is only applica in cases where the point at which the reaction is complete can be determined acc rately by means of some distinctly visible phenomenon occurring in the solution to analysed. The first introduction of this method is due to Descroizilles, who, at th close of the last century, applied it to the valuation of bleaching powder by means indigo-solution: since which time it has been gradually extended until it has gro into a distinct and most important branch of analysis, which, in most cases, is at le equal in accuracy to the method by weight, while it is greatly superior in speed a facility of execution.

The methods of qualitative analysis consist in bringing the substance under e amination into contact with other bodies of known properties, and observing t phenomena which ensue. These phenomena consist in alterations, either in state aggregation, form, or colour, depending upon some chemical change. All bodies whi we employ for this purpose, we call by the general name of *reagents*, the ensuing ph nomena are called *reactions*. Acids, bases, salts, and simple bodies (elements) alike used as reagents.

By means of reagents, the chemist puts questions to the substance under examin tion, enquiring whether it contains this or that group of chemically similar elemen or only this or that member of such group. If the question be put correctly —*i.e* all the conditions under which the reaction expected can be produced by the reag employed be carefully observed, the answer is decisive as to the presence or absence the element, or group of elements, sought: if, on the other hand, these conditions *i.e.* the properties and chemical relations of the bodies formed by the chemical chan which constitute the reaction, have been wholly or partially neglected, the answer, not certainly erroneous, is at least of doubtful accuracy.

Reagents may be employed either in *the wet way* or in *the dry way*. In the wet w the reagent in solution, *i.e.* in the liquid form, is brought into contact with the su stance to be examined, which is also in the liquid form. In the dry way, the t bodies are brought together in the solid state, and subjected to a high temperatu Of the utmost importance in analysis by the latter method, is the knowledge of t use of the blowpipe, and of the behaviour of bodies in the different flames which c be produced by it. (See BLOWPIPE.)

Many reagents exhibit the same, or a similar behaviour, with a certain fixed numb *i.e.* with a *group*, of elements, and with most of the compounds of these elements; a can therefore, be employed for the division of the elements into groups. Such reage are termed *general reagents*. Others serve for the further distinction of the seve members of such groups: their selection depends upon the knowledge of the spec characteristic behaviour to such reagents of each single element, or of each of several compounds. Such reagents are called *special* or *characteristic reagents*. Th number is much greater than that of the general reagents, their nature being as vari as that of the substances which can come under examination. their selection depe upon the solubility or insolubility, colour, or other physical or chemical properties the new compounds to which they give rise. They may frequently be employed ciprocally: thus, starch is a characteristic test for iodine, and reciprocally, iodine i characteristic test for starch.

The analyst has not only to establish that this or that body is present in a compou but he has also to prove that no other body is present besides those which he actually found. Hence it is evident that he must not treat the substance under amination with any reagent indiscriminately. He must follow a certain fixed ord

he application of reagents, which will be the same for all
ver, let their elements be what they may. This systematic
departed from or abbreviated without danger, except in
enced chemist, consists in the employment of general reagents
on of groups of elements possessing certain common chemical
the recognition of each member of such groups by the em-
reagents. If the object be not a complete and accurate
ablish the presence or absence of some particular body, the
in many cases be employed at once, without previous
s.

ne in the qualitative analysis of a solid body, is to subject
ation in the dry way, by which means important information
frequently be obtained: after which it is dissolved, and its
y examination in the wet way. The course of qualitative
of 3 parts:

nation in the dry way.
sion into the liquid form.
ation in the wet way.

treat successively of each of these operations.

I. *Preliminary Examination.*

an accurate observation of the physical properties of the
r, hardness, specific gravity, &c.): but chiefly in observing
mperature, either alone, in contact with air, or with some
produces either decomposition or simple solution.

d alone in a dry test-tube, on charcoal, or on platinum-foil.
s acids, ammonium-, arsenic-, and mercury-compounds are
arbon burns when heated in the air. If water is evolved,
or alkaline to litmus. If gases are evolved, observe whether
l if so, whether their combustion is sustained or intermittent.
ecomposed by heat, generally with evolution of inflammable
on: when heated with strong sulphuric acid and bichromate
carbonic anhydride, which gives a white precipitate with
dies which are very rich in oxygen, nitrates, chlorates, per-
es, deflagrate when heated on charcoal. Most alkaline, and
, melt without volatilising or changing colour; after strong
alkaline to test-paper. Many silicates (especially zeolites)
t of them is exposed in platinum-tongs to the blowpipe flame.
up: other salts, *e. g.* chloride of sodium, decrepitate. Of
tin, bismuth, cadmium, zinc, tellurium, fuse readily before
incrustation of oxide; gold, silver, and copper, fuse with
crustation; iron, nickel, cobalt, molybdenum, wolfram, and
sible. The oxides and salts of the earthy and alkaline-earthy
difficultly fusible; they become vividly incandescent, with a
change colour; the earths, after ignition, are not alkaline to
nd salts of some metals assume a darker colour when heated:
n, columbium (niobium), and antimony, become yellow: those
y (and chromates), become dark-brown.

ignition on charcoal, is moistened with a drop of a solution
gain strongly heated before the blowpipe.—Alkaline phosphates
e a *blue glass:* the earths, earthy phosphates, silica and many
ible mass: zinc-oxide and titanic anhydride become *yellowish-*
luish-green: antimonic and columbic anhydrides, *dirty-green:*
nhydrides, *flesh-red:* baryta, *brown* or *brick-red:* glucina,

ated on platinum-wire (if a metallic salt, on charcoal) in the
d the colour of the outer flame observed.—A *yellow* colour in-
potassium: a *carmine-red*, lithium or strontium. The yellow
um, completely overpowers those of the other alkaline metals:
rved through dark blue glass, the yellow rays are cut off, and
n and lithium are plainly visible, even in presence of a large
dish-yellow colour indicates *calcium*; a *yellow-green*, barium or
upric oxide, phosphoric, boric, or tellurous acid; a *blue*, arsenic,
, or cupric chloride. In many cases, the colour is rendered
bstance be previously moistened with hydrochloric acid, or a

little chloride of silver added: phosphates and borates should be moistened wit sulphuric acid.

The delicacy and sharpness of these chromatic indications are greatly increased by a method of observation lately introduced by Bunsen and Kirchhoff. It consist mainly in igniting a metallic salt on platinum wire, in a feebly luminous and nearly monochromatic flame, such as that of a Bunsen's gas-burner, and observing th flame through a prism. Very characteristic spectra are then produced, containing luminous coloured bands coincident in position with certain of Fraunhofer's lines *Sodium* gives a spectrum reduced to a single bright narrow band; *lithium*, a bright red and a fainter yellow band; *potassium*, a spectrum nearly resembling the ordinary solar spectrum in the middle, but characterised by a bright line near the red extremity, and a fainter line near the violet end of the spectrum. The *strontium* spectrum consists of a broad bright orange band, with some fainter red bands; th *calcium* spectrum, of a broad bright green band, a somewhat narrower bright orang band, and some fainter yellow bands; and that of *barium*, of several bright green yellow and orange with two faint red bands. The sodium reaction is extremely delicate, sufficing for the detection of a quantity of sodium as small as $\frac{1}{3000000}$ o a milligramme; distinct indications are likewise obtained with $\frac{9}{10000000}$ of a milli gramme of lithium, $\frac{1}{1000}$ milligramme of potassium and barium, $\frac{6}{100000}$ milligramme of strontium, $\frac{6}{10000000}$ milligramme of calcium. (For details see the article LIGHT; als Pogg. Ann. cx. 161; Chem. Soc. Qu. J. xiii. 270.)

4. *The substance is heated on charcoal in the reducing flame with carbonate o sodium, or with carbonate of sodium and cyanide of potassium.*—Most arsenic compounds give a smell of garlic. All sulphur-, selenium-, and tellurium-compounds, giv an alkaline sulphide, selenide, or telluride, which, when moistened, leaves a blac stain on a clean silver plate. Tin-, silver-, copper-, and gold-compounds give malleabl shining scales: compounds of nickel, cobalt, iron, molybdenum, wolfram, and th platinum-metals are reduced to a grey infusible powder: no incrustation is formed i any of these cases. Antimony-compounds give a *brittle* metallic globule, and a whit incrustation: bismuth, a *brittle* globule and a brown-yellow incrustation: lead, *malleable* globule, and a yellow incrustation. Zinc and cadmium are not reduced t the metallic state, but give, the former a white incrustation, not volatile in the out flame, the latter, a brown-red incrustation.

5. *The substance is heated in a glass tube, open at both ends, held obliquely.*—Th following substances yield gases having a peculiar smell: sulphides, of burning sulphur selenides, of horseradish; arsenides, of garlic; many ammonium-salts, of ammonia fluorides (especially on addition of microcosmic salt), of hydrofluoric acid. A metall sublimate indicates arsenic- or mercury-compounds: a white sublimate is given b arsenides (crystalline), by antimonides and tellurides, (fusible), and by many ammonium salts. A fused sublimate is given by the higher sulphides (brown-yellow), by selenide and selenium (blackish-red), and by sulphide of arsenic (yellow). All hydrated sal or substances containing hygroscopic water yield drops of water, the acid or alkali reaction of which should be ascertained.

6. *The substance is heated in contact with metallic zinc and dilute hydrochloric sulphuric acid.*—Many metallic acids are reduced to lower oxides by this treatmen a change of colour being produced. Titanic acid gives a *violet* colour: tungstic ac and the chlorides of tantalum and columbium, a *blue*: molybdic acid, *blue*, changing *green* and dark-brown: columbous acid, *blue*, changing to *dark brown*: chromic ac *green*, iodic acid, *brown*, or if starch be added, *blue*.

II. *Solution of Solid Bodies.*

After having ascertained by the preliminary examination in the dry way, to wh class of bodies the substance under examination belongs, the next step is to bring into the liquid form, in other words, to *dissolve* it. In order to effect this, it is genera necessary, when the nature of the substance allows it, to reduce it to a fine powder pounding in a mortar, and, if necessary, by subsequent levigation with water. T is indispensable in the case of minerals, especially of silicates, and of all other difficul soluble, insoluble, or difficultly decomposible compounds. If the substance conta organic matter, this should be removed before proceeding further, as its presen materially interferes with the reactions of many mineral compounds. This may ge rally be effected by heating the substance strongly for some time in contact with (more speedily with oxygen), until the whole of the carbon is converted into carbo anhydride. In many cases, the oxidation of the carbon is facilitated by dropping nit acid on the heated substance.

The solvents which are usually employed in the analysis of inorganic bodies water, hydrochloric and nitric acids, and aqua-regia. The finely-powdered substa is first boiled with from 12 to 20 times its weight of *distilled water*, in order to ascert

lity or insolubility therein. If it be not completely dis-
l off from the residue, and a drop or two of it evaporated
when, if the substance is partially soluble in water, a dis-
substance is completely insoluble, there is no residue after
ase, the solution is tested with litmus paper to see whether
lkaline reaction, and set aside for further examination.
er is then treated successively with *dilute* and *concentrated*
attention being paid to the nature of the gases, if any,
eparation of solid products of decomposition. Carbonates
with effervescence; peroxides, chromates, and chlorates
ydrocyanic acid; many sulphides, hydrosulphuric acid;
sulphurous anhydride, with separation of sulphur in the
ron, zinc, tin, &c.) evolve hydrogen; or, if arsenic or an-
r antimonide of hydrogen. If hydrochloric acid does not
ance, it generally effects the complete separation of one
reason the solution should be separated from the residue,
residue may consist of compounds undecomposible by
ted in the original substance; or of insoluble compounds
of the original substance by hydrochloric acid. Thus
olysulphides, pulverulent or gelatinous silica from many
tungstates, &c.; or if lead, silver, or subsalts of mercury
s of these metals will be formed.

pletely soluble in hydrochloric acid, the insoluble residue
nitric acid and *aqua regia.* In many cases (*e. g.* with
s, tungstates, &c.), these compounds act merely as solvents;
exert an oxidising action. Thus, most sulphides, when
rate sulphur, which, by prolonged digestion with the acid,
which swim on the surface of the liquid, or disappears
to sulphuric acid, which may be detected in the solution,
salt with the dissolved metal. Sulphide of lead is con-
phate of lead: sulphides of antimony and tin into white
ury is insoluble in nitric acid, readily soluble in aqua regia.
oluble in nitric acid: the only metals not attacked by it
rarer metals found in platinum-ores (with the exception
soluble in nitric acid). Gold and platinum are soluble
mony are not dissolved by nitric acid, but are converted
in the acid; they are readily soluble in aqua regia (or
e of potassium), if excess of nitric acid be avoided.

bstance is neither dissolved by successive treatment with
ecomposed or attacked by them as to give an idea of its
oluble, in order that its constituents may be determined
od of doing this frequently depends upon the results of
The following are the principal insoluble (or difficultly

trontium, calcium, and lead). When heated on charcoal
ey give an alkaline sulphide: sulphate of lead gives also
; it is blackened by sulphide of ammonium, and soluble
m. They are rendered soluble by fusion with 3—4 pts.
ating the fused mass with water, the solution contains
, and the residue the base, as carbonate, which is now
In this and in all the following cases, the substance
as possible before fusion. The sulphates of strontium,
osed (the first not completely), by digestion with a solu-
hate of calcium is somewhat soluble in water.

Vhen heated before the blowpipe with microcosmic salt,
e fused bead. They are rendered soluble by fusion with
(or hydrate of barium), treatment with hydrochloric acid,
cid, when the silica remains insoluble; or by treatment
ric acids.

c.)—When gently heated with concentrated sulphuric
acid, which corrodes glass: if silica be present, fluoride
h gives a precipitate on contact with water. They are
pts. alkaline carbonate, with addition of silica if neces-

s.—They give a blue infusible mass when heated with
endered soluble by fusion with 3—4 pts acid sulphate of

5. *Chromic oxide* (chrome-iron-ore).—It gives a green bead in both flames wit borax or microcosmic salt. Chrome-iron-ore is decomposed by successive fusion wit acid sulphate of potassium, and with alkaline carbonate and nitre.

6. *Binoxide of tin*, and *Antimonic anhydride*.—They are coloured yellow by sul phide of ammonium, and dissolved by digestion in excess of the reagent: when heate on charcoal with sodic carbonate, they yield, the first a malleable, the second a brittle metallic globule. They are rendered soluble in acids by fusion with 3—4 pts. alkalin carbonate.

7. *Tantalic, tungstic, titanic*, and *columbous anhydrides*.—They give with micro cosmic salt a blue, violet, or (in presence of iron) a blood-red, bead: with zinc an hydrochloric acid, a coloured solution. They are rendered soluble by fusion with 6 pts acid sulphate of potassium.

8. *Chloride, bromide, iodide, of silver; Sulphides of molybdenum, lead, &c.*—Chloride bromide, and iodide of silver, are soluble in cyanide of potassium: when heated on char coal with sodic carbonate, they yield metallic silver. Insoluble sulphides give o sulphurous anhydride when heated: sulphide of molybdenum gives a yellowish-green bead with microsmic salt, and is converted by roasting into molybdic anhydride, whic gives a blue colour with zinc and hydrochloric acid.

9. *Metals* (osmide of iridium, or residues of platinum-ores).—The insoluble sub stance has metallic lustre, or is a black powder, not affected by ignition. It is rendere soluble by mixture with chloride of calcium and ignition in a stream of chlorine; o by fusion with potash and chlorate of potassium.

10. *Carbon*.—The insoluble substance is black (as diamond, colourless): it di appears when strongly ignited in an open platinum crucible, or before the blowpipe It detonates when fused with nitre, forming carbonate of potassium; and yield carbonic anhydride when ignited with oxide of copper.

If the preliminary examination furnishes no distinct idea as to the nature of th insoluble substance, it must be fused with four times its weight of carbonates of potas sium and sodium, the fused mass exhausted with water, and the residue treated wit hydrochloric acid. If the substance contains any easily reducible metal (arsenic antimony, tin, lead, bismuth, &c.) it must not be fused in a platinum crucible.

III. *Qualitative Analysis of Solutions.*

The first steps to be taken in the qualitative analysis of solutions are to ascertai whether the solution is neutral, acid, or alkaline to test paper; and whether it contain any non-volatile constituents. For the latter purpose, a small portion of it is care fully evaporated on platinum-foil: when, if non-volatile compounds are present, residue is left which does not disappear when strongly heated, and should be submitte to the preliminary examination above described.

These precautions are of course unnecessary when the solution has been made b the analyst himself, as described in Section II.: but they should never be neglecte when the substance to be examined is already in the liquid form, since, if carefull performed, they may enable him to conclude at once as to the presence or absence o whole groups of bodies. Thus it is evident that a solution which, after *careful* evapo ration, leaves no fixed residue, cannot contain any non-volatile metallic salts. A solution *neutral* to test-paper can generally contain only salts of the alkaline or alkalin earthy metals, since the salts of most other metals have an acid reaction. An *alkalin* solution (in which no non-volatile organic compounds are present), cannot contain an metals whose salts are insoluble in alkaline liquids: if the alkaline reaction be cause by the presence of an alkaline carbonate, the presence of the alkaline-earthy metal is impossible. If, however, non-volatile organic compounds are present, an alkalin solution may contain salts of copper or sesquisalts of iron, as well as such oxides cyanides, sulphides, &c., as are soluble in cyanide of potassium or alkaline sulphides The presence of certain acids implies the absence of certain metals, and *vice versa* thus the same acid solution cannot contain sulphuric acid and barium, hydrochlori acid and silver, &c. Silver need not be looked for in an alloy soluble in hydrochlori acid, nor gold, antimony, tin, &c. in one soluble in nitric acid.

It is advisable, when possible, to examine for acids and metals in separate portion of the solution.

a. Examination for Metals.

The systematic course of examination for metals which is now almost exclusivel employed, depends upon the behaviour of metallic salts in solution towards the follow ing general reagents: *hydrochloric acid, hydrosulphuric acid, sulphide of ammonium* and *carbonate of ammonium*. It will be observed that all these reagents are volatile so that in their application no substance is introduced into a solution which canno

on of temperature. Their application depends upon
llic chlorides and sulphides, and of the carbonates of
he metals. By means of these general reagents, as
metals are divided into certain groups, which are
he solution under examination; by which proceeding
al member of each group is considerably facilitated.
o which the metallic elements are thus divided:
insoluble, or difficultly soluble in water or dilute acids.
ury (the last as sub-salts). These metals are not gene-
nselves, but are included in the group next following,

sulphides are insoluble in water or in dilute acids.
n their slightly acid solution by hydrosulphuric
d into two subdivisions according to the behaviour of
nmonium.
e sulphides possess acid properties. Their sulphides
es (sulphides of ammonium, potassium, or sodium),
o-salts, which are generally analogous to the oxygen
n being replaced by sulphur. They are arsenic, anti-
idium, selenium, tellurium, molybdenum, wolfram,

e sulphides do *not* possess acid properties, not com-
and so being insoluble therein. They are lead, silver,
ium, palladium, rhodium, osmium, ruthenium. (Sul-
lphide of potassium or sodium: sulphide of copper is
ammonium.)
re not precipitated by hydrosulphuric acid, but which
of ammonium, from acid solutions. This group

h are precipitated as *sulphides.* They are nickel,
m, zinc. Their sulphides are insoluble in water, but
volution of hydrosulphuric acid: hence they are not
phuric acid from acid solutions, and not completely
re however completely precipitated from an acid solu-
the acid being neutralised by the ammonia contained

h are precipitated as *hydrates.* They are aluminium,
m, thorium, yttrium, erbium, terbium, cerium, lan-
antalum, columbium, chromium. (The first ten metals
s *metals of the earths,* or *earthy metals*). They do not
t way, and so are not precipitated by hydrosulphuric
Their hydrates, however, being insoluble in water, are
or acid solutions by sulphide of ammonium, the acid
tion being neutralised by the ammonia of the reagent,
es.
rthy and alkaline-earthy metals with non-volatile acids
&c.), being soluble in dilute acids and insoluble in
by sulphide of ammonium.
sulphides and *hydrates* are soluble in water; which,
y hydrosulpuhric acid or sulphide of ammonium from
des the *alkaline-earthy* and *alkaline* metals. They are
their behaviour to carbonate of ammonium in presence

ch are precipitated by carbonate of ammonium.
cium. Their normal carbonates are insoluble in water

h are *not* precipitated by carbonate of ammonium.
n, sodium, lithium, ammonium. Carbonate of magne-
e in chloride of ammonium: the carbonates of the other
re soluble in water. The different solubility of their
the further detection of the metals of this subdivision.
he alkaline-earthy metals (barium, strontium, calcium,
: and Group 4 comprises the alkaline metals.
s in a compendious form the behaviour of all the
above enumerated.

Behaviour of Metallic Solutions with Hydrochloric Acid, Ammonium,

Hydrochloric Acid.	**Hydrosulphuric Acid.**		
Metals which are precipitated as *chlorides* from their neutral or acid solutions by *hydrochloric acid.**	Metals which are precipitated as sulphides from their hydrochloric acid solution by *hydrosulphuric acid.*		Metals whose salts are partly *reduced* in an acid solution by *hydrosulph. acid*, with separation of sulphur.*
	Soluble in sulphide of ammonium.	*Insoluble in sulphide of ammonium.*	
Lead (partially), white, crystalline, soluble in hot water, precipitated thence by sulphuric acid. **Silver**, white, curdy, soluble in ammonia, precipitated thence by nitric acid. **Mercury as subsalt**, white, finely-divided, blackened by ammonia.	**Arsenic** (yellow). **Antimony** (orange). **Tin*** (brown or yellow). **Gold** **Platinum** (black-brown). **[Iridium]** **Molybdenum**† (brown). **[Selenium]** (red-yellow). **[Tellurium]** (black).	**Mercury*** **Silver** (black). **Lead**† **Copper** **Cadmium** (yellow). **Bismuth** (brown). **[Palladium]**‡ **[Osmium]** (black-brown). **[Rhodium]** **[Ruthenium]**	**Iron as ferric salt.** The solution becomes colourless, and contains a ferrous salt. **Chromium as chromate.** The solution becomes green, and contains a chromic salt.
* In a saturated solution of a barium-salt, hydrochl. acid gives a white precip. readily soluble in water. In an *alkaline* solution, hydrochloric (or nitric) acid gives a precipitate in presence of *Silicic* *Boric* *Antimonic* acids; *Tungstic* *Molybdic* *Benzoic* or of those metals whose oxides are soluble in alkalis (aluminium, &c., soluble in excess of acid); or of *cyanides* and *ferrocyanides*; or of those *sulphides* which are soluble in sulphide of ammonium. In presence of soluble *polysulphides* or *hyposulphites*, sulphur is separated.	* SnS is brown, SnS^2 yellow. From the solution of SnS in sulphide of ammonium, hydrochl. acid precipitates yellow SnS^2. † The sulphides of *tungsten* and [*vanadium*] are not precip. by hydrosulph. acid from an acid solution: but they are when their solution in sulphide of ammonium is decomposed by an acid.	* Mercury as protosalt is precip. white by a little hydrosulph. acid; black by excess. † Lead is only precip. completely from dilute, not too acid, solutions. ‡ The sulphides of all the platinum-metals are precipitated very slowly.	* Sulphur is also separated in presence of free *chlorine*, bromine, and iodine, of *sulphurous*, nitrous, *hypochlorous*, chloric, *iodic*, bromic *acids*, &c.; and generally in presence of easily reducible salts of metals which are not precip. as sulphides from an acid solution.

The metals enclosed thus [ ] are very rare, and

lphide of Ammonium, and Carbonate of

onium.		**Carbonate of Ammonium.**	
e of ammonium, in presence nium. monia before adding sulphide		Metals which are precipitated neither by ***hydrosulphuric acid*** nor by ***sulphide of ammonium. Carbonate of ammonium,*** in presence of chloride of ammonium,	
s: ammonia.	***As Salts:*** also prec. by amm.	***precipitates****	***does not precip.***
potash. (colourless). en). or Nio- otash. generally colourless.	a. in presence of phosphoric acid. **Magnesium** (crystalline). b. in presence of phosphoric, oxalic, boric or hydrofluoric acid. **Calcium*** / **Strontium** / **Barium** } (white). as phosphates, oxalates, borates, or fluorides.	**Barium** / **Strontium** / **Calcium** } (white). as carbonates.	a. precipitable by phosphate of ammonium (and ammonia). **Magnesium** (crystalline). b. not precip. by phosphate of ammonium. **Potassium.** **Sodium.** **Lithium.*** **Ammonium.**
hosphoric lso precip. n potash. sion with	* The alkaline-earthy phosphates are insol. in potash, sol. in acetic acid. Oxalate of calcium is insol. in acetic acid.	* The precipitation is not complete unless ammonia is added, and the whole heated to boiling.	* A concentrated solution of a lithium-salt is precip. by phosph. sod. on heating.

s.

If we suppose the case of a solution containing all the metals, it is obvious that, by the successive application of each of these general reagents, we shall separate, first, by hydrochloric acid, those metals whose chlorides are insoluble; secondly, by hydrosulphuric acid, those metals whose sulphides are insoluble in dilute acids; thirdly, by sulphide of ammonium, those remaining metals whose sulphides or hydrates are insoluble in neutral or alkaline liquids; and lastly, by carbonate of ammonium, those metals whose carbonates are insoluble: so that at last we have only the alkaline metals left in solution. In order, however, to effect the complete separation of each group, the general reagents must be employed *in the order* above stated: for sulphide of ammonium would precipitate those metals whose sulphides are insoluble in dilute acids, as well as those whose sulphides are only insoluble in neutral or alkaline liquids; and carbonate of ammonium, if employed before the other reagents, would precipitate most of the metals of Groups 1 and 2, their carbonates being also insoluble.

The following rules, the importance of which will be obvious on the least reflection, must also be strictly observed.

1. The mineral acid employed to acidify the original solution (when it is not already sufficiently acid), is either hydrochloric or nitric acid. Both are employed dilute, and not in sufficient quantity to interfere with the formation of the sulphides of Group 1. Hydrochloric is generally preferable to nitric acid: for it serves as a general reagent, separating at once those metals which form insoluble chlorides. If nitric acid be employed, these metals will be found in the precipitate by hydrosulphuric acid.

2. The precipitation by each general reagent must be complete. To ensure this, the reagent must be added gradually, allowing the precipitate to subside between each addition, until no further precipitate is produced. In the case of hydrosulphuric acid, the precipitation is complete when the solution, after agitation, still smells strongly of the gas. Gentle heat facilitates the separation of precipitates in almost every case. Arsenic (as arsenic acid), gold, platinum, iridium, rhodium, and molybdenum, are precipitated very slowly by hydrosulphuric acid. Tungsten and vanadium are not precipitated by hydrosulphuric acid from an acid solution: they are, however, included in Group 1, because their sulphides (obtained by adding sulphide of ammonium and then hydrochloric acid), are insoluble in acids, but soluble in sulphide of ammonium.

3. Each group, when precipitated, must be thoroughly freed by washing with water from all members of the subsequent groups, which may be contained in the solution. This washing is effected, according to circumstances, either on a filter, or by decantation. If the precipitate contains any easily oxidable sulphides, a little hydrosulphuric acid must be added to the wash-water (if the sulphide is insoluble in dilute acids, *e.g.* sulphide of copper), or a little sulphide of ammonium (if the sulphide is soluble in dilute acids, *e.g.* sulphides of iron and manganese), in order to prevent the partial oxidation of the sulphide by exposure to the air during the washing of the precipitate. After the precipitation of each group, it is advisable to ascertain the presence or absence of any members of the succeeding groups, by carefully evaporating on platinum-foil a moderate quantity of the filtrate; if, after ignition, there is no distinctly visible residue, non-volatile substances need not be looked for further. It is obvious that, if these two precautions (complete precipitation and thorough washing) be neglected, metals belonging to one group are liable to be found among those of another group; and consequently, as the analysis proceeds, reactions will be obtained which will be the source of great perplexity to the unpractised analyst.

Each group of metals having been separated by the application of general reagents, the presence or absence of each member of each group is ascertained by means of special or characteristic reagents. It seldom happens that the number of elements contained in any inorganic compound exceeds ten or twelve: and in most cases some distinct idea of the nature of its principal constituents is afforded by the results of the preliminary examination. In metallic minerals and alloys, the heavy metals are chiefly to be looked for: in silicates, the earthy, alkaline-earthy, and alkaline metals, iron, and manganese. It frequently happens that important information may be derived from the colour of a precipitate or of a solution. Thus solutions of cupric, chromic, molybdic, and vanadic salts, are blue or green; those of nickel-salts, green; those of ferrous-salts, light bluish-green; those of chromates, gold-salts, ferric- and platinic-salts, yellow, with a red or brown tinge; those of cobalt-salts, red, &c. These colours are not perceptible when the amount of metal present is very small, or when they are masked by the presence of other metals, the colour of whose solutions is complementary to them.

In order to show the systematic method by which the members of each group are detected in presence of each other, we will now briefly go through the most important groups mentioned in the table.

1. *Precipitate produced by hydrochloric acid.*—Chloride of lead is soluble in a large quantity of water, especially on boiling; chloride of silver, in ammonia; subchloride

monia. (The addition of either hydrochloric or nitric
in presence of such acids, hydrates, cyanides, sulphides
liquids, but insoluble in water; or a precipitate of
ulphide or hyposulphite, or a white precipitate, readily
urated solution of a barium-salt.)
ydrosulphuric acid.

sulphides. — Sulphide of arsenic is soluble in acid sul-
arbonate of ammonium, the sulphides of antimony and
lphides are dissolved in aqua-regia, and the solution is
atus, antimony and arsenic are detected by the behaviour
ounds; tin, after its separation by zinc, by its solubility
e reaction of its solution with chloride of mercury.

ine sulphides. — The precipitate is treated with nitric
l sulphate of lead may remain undissolved. In the
phuric acid; silver, by hydrochloric acid; bismuth by
or by water if no excess of acid is present; copper, by
al solution, or by ferrocyanide of potassium; cadmium,
oniacal solution by hydrosulphuric acid, after the addi-

lphide of ammonium. — The precipitate is digested with
ld: chromium, zinc, aluminium, and glucinum are found
contained in the residue: cobalt, nickel, and manganese
nmonia, and so are not precipitated by it: iron, uranium,
kaline-earthy phosphates, oxalates, &c., are precipitated
f chloride of ammonium. The hydrates of uranium and
dily soluble in carbonate of ammonium: ferric hydrate
-earthy salts are insoluble. Ferric salts are detected
ide of potassium; the alkaline-earthy salts by appro-

arbonate of ammonium. — The metals which compose
calcium) are distinguished by the different solubility
chromates, &c.: and by the colours which they com-
, or to that of burning alcohol.

successive application of the above general reagents,
nd the alkaline metals. Magnesium is detected by its
ammonium; the alkaline metals by the colour which
alcohol flame, and by the different solubility of their
Ammonium is always sought for in a separate portion of
cted by the evolution of ammonia when any of its salts
or alkaline earth.

is decomposed by the salts of most of those metals which
ric acid from an acid solution, a metallic sulphide being
posed to employ this compound as a general reagent
d, and so to avoid the unpleasant smell of the latter.
s not as yet been generally adopted.

so be employed as a general reagent. When a solution
ken up with excess of this salt, in the cold:

	Are not precipitated.	
	Silver.	
	Lead.	
	Iron	as protosalts.
	Nickel	
	Cobalt	
	Manganese	
	Zinc.	
	Cerium.	
	Yttrium.	
	Glucinum.	
	Magnesium.	
	Calcium.	
isalts.	Barium.	
	Strontium.	
salt, or as chromic acid.	Ammonium.	
cid.	Lithium.	
	Sodium.	
	Potassium.	

Mercury, platinum, palladium, rhodium, iridium, and gold are precipitated by carbonate of barium only when they are present as oxygen-salts, not when present as chlorides, &c. Arsenic, antimonic, phosphoric, selenic, and sulphuric acids are not precipitated by carbonate of barium until the solutions of their salts have been acidulated with nitric or hydrochloric acid. Carbonate of barium is not much used as a general reagent; it is however employed with advantage for the separation of the metals which are precipitated by sulphide of ammonium, since it precipitates completely those which are present as sesquisalts, while the protosalts remain in solution.

When, in the course of a systematic qualitative analysis, one or more members of the different groups have been recognised as constituents of the substance under examination, by means of the reactions above enumerated, the results must be confirmed by certain special reactions, which will be detailed at length in the articles devoted to the several elements.

b. *Examination for Acids.*

The qualitative detection of acids, is, on the whole, more difficult than that of metals; still, with due care, it may be accomplished with great precision. In most cases, the preliminary examination, as well as the nature of the metals already found, give information as to what acids should especially be looked for. The knowledge of the solubility of different salts, and of the reactions of their aqueous solutions with vegetable colours, is of the greatest importance in this examination. By heating the substance either alone or with concentrated sulphuric acid, the presence or absence of *organic* and *volatile inorganic* acids is at once ascertained, these acids either volatilising undecomposed, or yielding volatile products of decomposition. For this purpose, a small portion of the dry substance is heated in a test-tube (not to boiling) with 3 to 4 times its volume of concentrated sulphuric acid; when, in the case of all acids which are either volatile without decomposition, or are decomposed by sulphuric acid at a high temperature, gases or vapours are evolved, the properties of which, in most cases, indicate the nature of the acids present.

1. *Non-volatile acids:* whose compounds evolve no vapours when heated with sulphuric acid, the mixture not being blackened—Silicic, Boric, Phosphoric, Sulphuric, Iodic, Arsenic, Selenic, Tungstic, Molybdic, Titanic acids.

2. *Acids which evolve a coloured gas*, the mixture not being blackened—Hydriodic, Hydrobromic, Bromic, Chloric, Hypochlorous, Nitrous acids.

3. *Acids which evolve a colourless gas, generally possesses an irritating smell and an acid reaction*, the mixture not being blackened—*a.* Volatile without decomposition: Hydrosulphuric, Hydrochloric, Nitric, Acetic, Benzoic, Succinic, Hydrofloric acids. The gas evolved is not inflammable, except in the case of hydrosulphuric acid — *b.* Decomposed — Cyanic, Chromic (evolves oxygen), Carbonic, Sulphurous, Hyposulphurous, Polythionic, Oxalic, Formic, Hydrocyanic, Sulphocyanic, acids, Ferro- and Ferri-cyanides. In most of these cases, the gas evolved is inflammable.

4. *Non-volatile organic acids:* Tartaric, Racemic, Citric, Malic, Tannic, Gallic, Uric acids. The mixture is blackened, and carbonic and sulphurous anhydrides and carbonic oxide are evolved.

The behaviour of a mixture of salts, when heated alone or with sulphuric acid, is often different from that of each individual salt under the same circumstances. Thus a mixture of a nitrate or chlorate with a salt of an organic acid, does not blacken when ignited, but commonly detonates: a chloride, in presence of a nitrate, when heated with sulphuric acid, evolves chlorine and red nitrous fumes; in presence of a chromate red fumes of chlorochromic acid; in a mixture of a sulphite and a nitrate, chlorate, chromate, &c., the sulphurous acid is converted into sulphuric acid; in a mixture of a sulphide and a sulphite, the two acids decompose each other, sulphur being separated, and the characteristic smell of each destroyed. Chloride and subchloride of mercury, and chloride of tin are decomposed with difficulty, if at all, by sulphuric acid.

From a solution containing volatile and non-volatile acids, the former may be separated by distillation with dilute sulphuric acid.

The general reagents usually employed in the examination for acids in the wet way are chloride or nitrate of barium; chloride of calcium; a mixture of sulphate of magnesium, ammonia, and chloride of ammonium; sesquichloride of iron; nitrate of silver and indigo-solution. By these reagents, the most important acids are divided into the following groups.

1. Acids which are precipitated by *chloride of barium:* —

a. from a solution acidulated with nitric or hydrochloric acid—Sulphuric, Selenic, Fluosilicic acids.

(the precipitate being soluble in acids) — Sulphurous,
Hydrofluoric, Oxalic, Chromic, Boric, Tartaric, Citric,
last five acids are not precipitated in presence of

ed by *chloride of calcium :* —
ly (the precipitate being soluble in acetic acid)—Phos-
Sulphurous, Tartaric, Citric acids, and Ferrocyanides.
id solution—Sulphuric, Hydrofluoric, Oxalic, Racemic

ed by *sulphate of magnesium, in presence of ammonia*
osphoric, Arsenic, Tartaric acids.

y *sesquichloride of iron :* —
anides (from a solution containing free hydrochloric
ic acids (from a neutral or acetic acid solution): Boric,
utral solutions only).
of free hydrochloric acid; Ferricyanides (brown), Sul-
l solutions only: Acetic, Formic, Sulphurous, Meconic

d by *nitrate of silver :* —
ly (precipitate being soluble in dilute nitric acid) —
osphoric, Arsenic, Arsenious, Chromic, Oxalic, Boric,
rmic acids: Silicic and Acetic acids from concentrated

(the precipitate being insoluble in dilute nitric acid).
ydriodic, Hydrocyanic, Sulphocyanic, Iodic, Hydro-
Ferri-cyanides.

ed, without the addition of an acid, by free chlorine
n-acids of chlorine, when free, and by metallic hypo-
not too dilute, by alkaline sulphides, and by caustic
ric acid, and heating, by chlorates, bromates, iodates,
drochloric acid, and heating (chlorine being evolved),
; also by chromates, selenates, tellurates, vanadates,
ates, and all peroxides.
tained in a soluble compound, the first step is to as-
tion to vegetable colours. When, as is frequently the
red, the solution, if acid, is neutralised by ammonia:
f nitrate of silver be not employed as a reagent, by
y of the heavy metals, as well as some alkaline-earthy
r solution is neutralised by ammonia, it is generally
olution all metals except the alkaline metals, before
which process, the presence or absence of metallic acids,
tes, oxalates, &c. will be ascertained. When this is
sary to substitute for the general reagents mentioned
base, since nitric acid forms no insoluble salts: thus
arium, must be employed in solutions containing lead,
We have already mentioned cases in which the addition
an alkaline solution will produce a precipitate. The
ated by the mere acidulation of their alkaline solutions:
Benzoic, Uric acids; Boric and Silicic acids from con-
same circumstances, a precipitate of sulphur is produced
cid or polysulphides: of iodine, in a solution containing
cid tartrate of potassium or ammonium, in a solution
of these metals. The nature of the metals found in
absence of one or more acids: generally speaking, a
ing one of the metals whose salts are used as general
examined for any of those acids which are precipitated
or hydrochloric acid need not be sought for in soluble
or silver respectively. In order not to overlook the
e organic acids, the acid solution is neutralised with
to dryness, and ignited: when the organic acid, which, if
ed undecomposed, is decomposed, with separation of

ble in water or acids are rendered soluble by one of the
the solution is examined for acids in the wet way. In-
vy metals are mostly decomposed by digestion with

sulphide of ammonium; sulphates of strontium and calcium by digestion with carbo of sodium: in both cases, the filtrate contains the acid, together with an excess of decomposing agent, while the metal is found in the residue. Insoluble salts of orga acids are decomposed by boiling with an alkaline carbonate; ferric salts of vola organic acids by digestion with ammonia: in both cases, the filtrate contains an alkal salt of the acid. Sulphides and all salts of the lower oxygen-acids of sulphur, yi sulphuric acid when digested with nitric acid, or any other oxidising agent.

The application of confirmatory tests is as necessary in the case of acids as in c of metals.—F. T. C.

The methods of *quantitative inorganic analysis* cannot be included in one artic The processes for the separation and quantitative estimation of each element are scribed in the article devoted to that element. The analysis of ashes, soils, mine waters, &c. and volumetric analysis, are also described in separate articles. We m here however describe a method, of general application, which is found useful in ma cases, viz.:

The Indirect method of Quantitative Analysis.—The usual method of termining the quantities of the several constituents of a compound or mixture, is separate each of them in the form of a definite compound, which can be collected a weighed, *e.g.* silver as chloride, barium as sulphate, &c., and calculate the weight the required constituent from the known composition of this compound. It sometin happens however, that the complete separation of certain substances is very difficu or even impossible, and in that case, recourse is had to a method of determinati which depends on the general principle that any number of unknown quantities m be determined simultaneously, if we can find between them a number of relatio equal to that of the quantities themselves; in other words, n unknown quantities m be determined by means of n equations.

Suppose for example, we have a mixture, either solid or liquid, containing potassi and sodium, in the form of hydrates or carbonates. Take two equal portions of t mixture (it is not necessary to know the weight of these portions), convert one port into chlorides, the other into sulphates, and weigh the two products. Let the sum the weights of the chlorides be a, and that of the sulphates b: the unknown weig of potassium x, and that of sodium y; then from the known atomic weights of t metals, their chlorides and sulphates, we have:

$$\frac{74{\cdot}5}{39}x + \frac{58{\cdot}5}{23}y = a$$

$$\frac{87}{39}x + \frac{71}{23}y = b$$

whence the quantities x and y may be determined.

Another form in which the indirect method may be applied to the determinatio two substances, is to bring them both together into a form in which they can weighed, *e.g.* as chlorides or sulphates, and determine the quantity of chlorine or sulphuric acid in the mixture; thus, suppose a mixture of potash and soda to be c verted into chlorides: let the sum of the weights of these chlorides be s, and let amount of chlorine in this mixture, determined as chloride of silver, be c; then if x the quantity of potassium and y the quantity of sodium, we have the two equation

$$\frac{\text{KCl}}{\text{K}}x + \frac{\text{NaCl}}{\text{Na}}y = s; \qquad \frac{\text{Cl}}{\text{K}}x + \frac{\text{Cl}}{\text{Na}}y = c$$

$$\text{or} \qquad \frac{74{\cdot}5}{39}x + \frac{38{\cdot}5}{23}y = s; \qquad \frac{35{\cdot}5}{39}x + \frac{35{\cdot}4}{23}y = s$$

whence x and y may be found.

If three substances are to be determined, *e.g.* barium, strontium, and calcium, should of course require three equations, which, in the case supposed, might be obtain by weighing the three substances, first as carbonates, then as oxalates, then as s phates. It is seldom, however, that the indirect method is applied to the determinati of more than two substances.

A case in which this indirect method of analysis is often applied, is to the det mination of a small quantity of bromine or iodine in presence of chlorine, as in t analysis of mineral waters. The chlorine and bromine are precipitated by a soluti of silver, and the mixed chloride and bromide of silver is weighed. It is then ignit in a stream of chlorine till all the bromine is expelled, and the resulting chloride again weighed: let the difference of the two weights be d: then, since chlorine a her in the proportion of their atomic weights, **viz.** as

3r $- \mathrm{Cl} = d; \qquad \frac{\mathrm{Br}}{\mathrm{Cl}} = \frac{80}{35\cdot5}$

3r $- \frac{35\cdot5}{80}\,\mathrm{Br} = d; \qquad \frac{44\cdot5}{80}\,\mathrm{Br} = d.$

3r $= 1\cdot797\ d.$

analysis can only be employed with advantage to ascertain
ubstances whose atomic weights differ considerably: with a
ame atomic weight, it cannot give any definite result; in
ch it involves become in that case identical.

NIC).—The analysis of organic substances divides itself,
es, into qualitative and quantitative. A further division is
Elementary or *Ultimate Analysis* and *Proximate analysis*,
the inquiry is to determine the ultimate elements, carbon,
e body is composed, or the proximate principles, such as
which those elements are grouped.

ARY OR ULTIMATE ORGANIC ANALYSIS.

posed of carbon, hydrogen, and oxygen, with or without
ssociated with sulphur and phosphorus: these are all the
ral organic compounds; those which are artificially prepared
whatever.
nation of these elements depends essentially on the process
organic compound is heated to redness in contact with free
nce which gives up that element with facility, it is com-
ements being separated either in the free state or in new

s. *Carbon* and *Hydrogen* are detected by burning the
in contact with oxide of copper or chromate of lead. The
to carbonic acid*, which if passed into baryta-water, forms
nate of barium, and the hydrogen into water, which collects
eceiver attached to the combustion-tube, or, if in very small
d visible by causing the vapour to pass through a narrow
sphoric anhydride, which if water is present, will be con-
id and dissolved. Carbon may also, in nearly all cases, be
due which remains when the organic substance is burned in
lose vessel, or heated with strong sulphuric acid; very few
fficient oxygen to burn away the carbon completely, even in
black residue of carbonaceous matter may be distinguished
inorganic origin, by burning slowly away when heated to
y of deflagrating with nitre and chlorate of potassium.
lies is for the most part given off in the free state when the
oxide of copper, but a surer mode of detecting it, especially
is to heat the substance in a test-tube with a considerable
sium or sodium. The carbon is then converted into car-
of the alkaline hydrate, while the whole or the greater
with the nitrogen to form ammonia, which may be detected
on litmus paper, and by the white fumes which it produces
in dilute hydrochloric acid is held over the mouth of the
ill more delicate test for nitrogen is the following, given by
the organic compound is fused in a test-tube with a small
ass is treated with water when cold; and the liquid boiled
partially oxidised by contact with the air. If it be then
chloric acid, the presence of nitrogen will be indicated by
ate of Prussian blue, or in case of very minute quantities, by
communicated to the solution.
lies is detected by igniting the compound with quick lime,
estroyed, the chlorine uniting with the calcium, in which
ay be dissolved out by water, and the chlorine precipitated
some organic compounds which contain hydrochloric acid
rochlorates of the organic bases, the chlorine may be imme-
of silver without this preliminary treatment.

---

e term *carbonic acid* is used for CO^2, in accordance with established
ct appellation *carbonic anhydride*.

Bromine and *Iodine* may be detected by similar treatment; *Fluorine* in the sam manner as in inorganic bodies.

Sulphur, *Phosphorus*, and *Arsenic*, are detected by igniting the organic compound with a mixture of hydrate of potassium, and nitre or chlorate of potassium, whereby those elements are converted into sulphuric, phosphoric, and arsenic acids, the presence of which may be demonstrated by reactions appropriate to each.

Metals occurring in organic compounds, remain for the most in the form of oxides or in the metallic state when the organic matter is burnt. Mercury may be detected in the ordinary way, by distillation with lime.

Quantitative Analysis. The first quantitative analyses of organic bodies were made by Gay-Lussac and Thénard. The substance to be analysed was mixed with a known weight of *chlorate of potassium*, and made up into small pellets, which were dropped one by one through a stopcock of peculiar construction, into an upright glas tube heated to redness, the gas thereby produced escaping by a lateral tube and being collected over mercury. The volume of gas was exactly measured, and the carbonic acid absorbed by caustic potash. The remaining gas consisted either of pure oxygen or (in the case of azotised bodies) of a mixture of oxygen and nitrogen, the proportions of which were determined eudiometrically (see ANALYSIS OF GASES). Knowing then the weight of the substance burned, the weight of the chlorate of potassium used and consequently the quantity of oxygen evolved, also the quantity of carbonic acid produced, and of the oxygen remaining after its absorption, sufficient data were obtained for calculating the amount of carbon, hydrogen, and oxygen in the substance analysed for, the difference between the total quantity of oxygen which had disappeared, and that which was consumed in burning the carbon (this latter quantity being equal in volume to the carbonic acid produced), gave the quantity which had united with the hydrogen to form water, and thence the amount of hydrogen was calculated.

This process was a great step in chemical science, and yielded many importan results; but it was difficult of execution, requiring great skill on the part of the operator; it was also inexact in the case of nitrogenous bodies, and totally inapplicable to liquid or volatile compounds. Berzelius simplified it by mixing the chlorate of potassium with common salt, thereby causing the combustion to go on gradually, and rendering it possible to introduce the whole of the material at once. He also collected and weighed the water produced, and thus greatly simplified the calculation.

Saussure and Prout burned the organic substance in an atmosphere of oxygen Prout's apparatus was so contrived that the substance was burnt in a measured volume of oxygen, and the volume of the gas remaining after combustion was compared with the original volume. Now, since the volume of carbonic acid produced by the combustion of carbon is equal to that of the oxygen consumed, while that which unite with the hydrogen to form water disappears altogether, it follows that if the organi substance contains oxygen and hydrogen exactly in the proportion to form water (as in acetic acid, sugar, &c.), the volume of gas remaining after combustion will be equa to that of the original oxygen: whereas if the proportion of hydrogen is greater (as i alcohol and ether), the volume of gas will be diminished by the combustion; and i the proportion of hydrogen is less (as in oxalic acid), the volume of gas will be increased. Hence, by absorbing the carbonic acid with potash and measuring the residual gas, sufficient data were obtained for calculating the quantities of carbon hydrogen, and oxygen.

The method now universally adopted for the estimation of carbon and hydrogen i organic compounds, consists in burning the compound with a large excess of oxide o copper or chromate of lead, and determining the quantities of carbonic acid and wate produced by the combustion, not by measure but by weight, the water being absorbe by chloride of calcium, and the carbonic acid by potash. The use of oxide of coppe was first introduced by Gay-Lussac and afterwards adopted by Ure; but it is to Liebi that we are indebted for those modifications of the process which have brought it t its present state of simplicity and exactness.

The process, as now performed, requires the following materials and apparatus.

Oxide of Copper.—Prepared by dissolving copper in nitric acid, evaporating to dryness, and calcining the residual nitrate in a crucible at a low red heat. As thu prepared, it is a dense, soft black powder, which rapidly absorbs water from the ai even before it is quite cold. If, however, it be very strongly heated, it aggregate into dense hard lumps, which, when broken into small pieces and sifted from the fine powder, yield an oxide well adapted for the combustion of volatile liquids. Oxide o copper may also be prepared by igniting copper turnings in a muffle. The oxide thu obtained is much harder and less hygroscopic than that prepared from the nitrate but it is not so easily mixed with an organic substance in the state of fine powder Oxide of copper must always be heated [illegible] immediately before use.

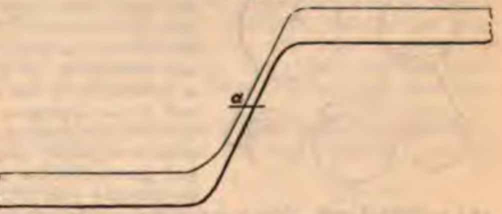
; the washed and dried precipitate in a crucible, and
rtar; it is then obtained in the form of a yellow-brown
tly hygroscopic; but to ensure its complete dryness, it
red bottles and heated over a lamp just before it is used.
the analysis of bodies containing nitrogen. The most
copper turnings, or thin foil rolled up into a spiral. As
urnings, is seldom clean, the metal should first be heated
roy any organic matter adhering to it, then pressed
heated in a current of dry hydrogen gas to reduce the
eat being continued as long as vapour of water continues
m of hydrogen afterwards kept up till the metal is cold.
e becomes covered with finely divided copper, which is
herefore be strongly heated over a lamp before use.
d by hydrogen from the oxide, is not applicable, being
acid at a red heat.

lass.—They must be capable of sustaining a strong red
n softening to such a degree as to be blown out by the
The best are made of the hard Bohemian glass (silicate
which may now be procured without difficulty. Glass
fit for the purpose. When the temperature required for
e tube should be protected by wrapping it in copper foil
t it from bending if it becomes softened by the heat.

of tube required vary according to the substance to be
f ordinary solids, tubes of half an inch internal diameter,
lapted: for solids containing very little carbon, a diameter
: for liquids, it is necessary to use tubes $\frac{6}{10}$ of an inch
, the length being greater as the liquid is more volatile.
imensions than the particular case requires, is not to be
waste of oxide of copper and increases the unavoidable

ughly cleansed and dried, are drawn out into an inclined

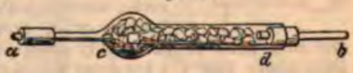
Fig. 8.



flame for an instant at the middle of the neck *a*, so
By this means, two tubes of the required shape are made

—The chloride of calcium for absorbing the water gene-
usually contained in a bulb-tube of the form shown in
ugh a perforated
ustion-tube, and
ork and narrow
with the potash-
le tube of caout-
-wool are placed
of calcium in its place. The cork *d* should be covered
may not vary in weight by loss or absorption of atmo-

Fig. 9.



atus presenting some advantages is the U-tube (*fig.* 10)
the combustion-tube, a small test-tube, *t*, which serves to
water, so that the chloride of calcium does not get so
sed several times without renewal. Chloride of calcium
in the form of a U-tube (*fig.* 11), having two bulbs, the one
f the tube being filled with chloride of calcium, and the
e the greater part of the water. This form of tube
last described (*fig.* 10), and does not appear to possess

The U-tube must always be used in preference to the straight tube (*fig.* 8), when the combustion is made in a stream of oxygen gas; because the current of gas being then rather strong, is apt to carry the vapour of water through the straight tube so quickly that a portion of it escapes uncondensed, whereas the U-tube detains it longer, and is more likely to ensure complete absorption.

Fig. 10.

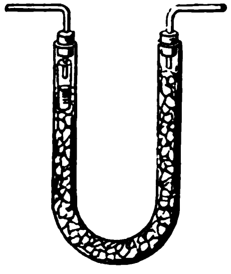
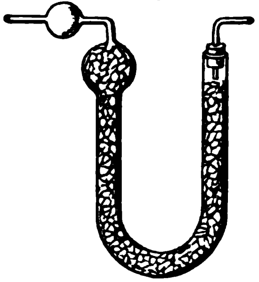
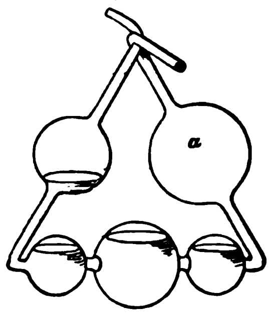


Fig. 11.



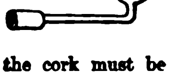
The chloride of calcium should be in the spongy state in which it is obtained by drying at about 200° C. The fused chloride is not so good for the purpose, because it often contains free lime, which absorbs carbonic acid as well as water.

Fig. 12.



Potash-bulbs. — The solution of caustic potash which absorbs the carbonic acid, is contained in a Liebig's bulb-apparatus (*fig.* 12), the form of which is so contrived as to keep the bubbles of gas in contact with the solution for a considerable time, without using a long column of liquid. The large bulb *a*, is connected with the chloride-of-calcium tube, the other extremity of the apparatus being left open. The solution of potash should have a density of about 1·27. If a weaker ley be used, the carbonic acid will not be completely absorbed, and stronger ley is apt to froth, and in that case a portion of it is sure to be forced out at the open end of the apparatus, thereby annihilating the result of the experiment. To fill the bulbs, the potash solution is poured into a small beaker or crucible, and drawn into the apparatus by means of a small suction-tube (*fig.* 13), attached to one end by means of a perforated cork. The quantity of liquid introduced should be sufficient to nearly fill the three lower bulbs, not more: the apparatus thus filled weighs from 40 to 50 grammes. Before weighing, it must be carefully wiped on the outside; and the inside of the tube, by which the liquid has entered, must be dried by means of a thin roll of filtering paper.

Fig. 13.



Corks.—The connection between the combustion-tube and the chloride of calcium tube, is made by a perforated cork. The greatest pains should be taken to select for the purpose good corks, smooth, and free from flaws. They should be softened by beating or by pressure. Immediately before the combustion, the cork must be thoroughly dried in an air-bath or sand-bath at a temperature a little above 100° C.: too great a heat must be avoided, as it renders the cork brittle.

Caoutchouc-tubes. — The chloride-of-calcium tube is connected with the potash-apparatus by a flexible tube of caoutchouc. These tubes are easily made by binding a piece of sheet-caoutchouc over a glass rod or tube of the proper size, and cutting it with a single stroke of a pair of scissors. If the edges be then pressed together, a perfectly tight tube will be made. The connections are made air-tight by tying with silk cord. Tubes of vulcanised caoutchouc, which may be purchased ready made, may also be used, and if of such a size as to require some force to fit them to the tubes, they make an air-tight joint without tying; they must however always be previously digested with a moderately strong solution of potash, in order to remove the sulphur, which is otherwise apt to get into the chloride of calcium tube and potash-apparatus.

Combustion-furnaces.—The combustion-tubes are heated either with charcoal or with coal gas: formerly charcoal was the only fuel employed; but gas-furnaces are

Furnaces have also been constructed for burning spirit;
terial in most countries renders its use very limited.
de of sheet iron, in the form of a trough (*fig.* 14), 22 to
igh. The bottom is 3 inches wide, wth narrow aper-
which form a sort of grate; the sides of the furnace are
hes apart at top. To support the combustion-tube, pieces
m D (*fig.* 15), are riveted to the bottom of the furnace at

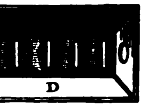
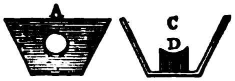


Fig. 15.



equal height,,with their edges ground flat, and correspond
t of the furnace A. The furnace is placed upon flat bricks,
r the grating unless the whole is purposely raised; the
d at pleasure. The heat produced by the charcoal fire
raised to any degree required, higher indeed than the
r; on the other hand, the use of charcoal as fuel has
erator is exposed to great heat and to the deleterious
the ash flies about to such an extent that it is always
bustions in a room apart from the general laboratory.
ng been considered desirable to use coal-gas as the fuel
d several forms of furnace have been contrived for the
however, that the problem has received a satisfactory
e constructed by Dr. Hofmann, and described by him in
Society, vol. xi. p. 30, whence the following details and

is essential that the gas while burning be mixed with
sure complete combustion and prevent smoking. This
ng a sheet of wire gauze between the flame and the orifices
his contrivance was indeed adopted in a form of furnace
some years ago by Dr. Hofmann, and has also been
furnaces thus constructed are very liable to get out of
speedy destruction of the wire gauze; moreover, they
for many combustions: hence they have not come into

ce, the mixing of the gas with air is attained by causing
of small orifices placed very close together. For this
rner is used,
consists of a
losed at top,
merous per-
e which are
nace, are 3
xternal, and
forations, of
are made in
0 rows of 15
lay cylinder
y bat's wing
h has been
urns with a
e, which en-
n renders it

Fig. 16.

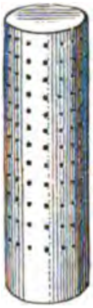
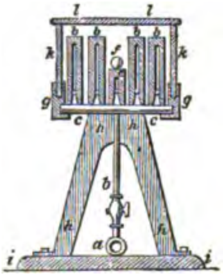


Fig. 17.



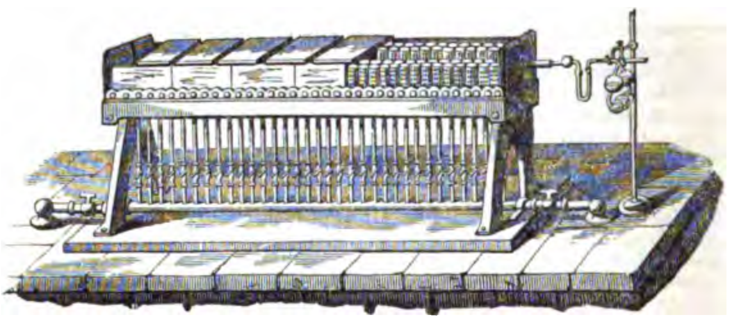
a. Horizontal gas pipe.
b. Vertical gas pipe provided with stop cock.
c c. Brackets for burners.
d d d d. High clay burners
e. Low clay burners.
f. Combustion tube.
g g. Wrought iron frame.
h h. Cast iron supports.
i i. Cast iron footplate.
k k. Sides of fire-clay.
l l. Cover plates of fire-clay.

atus is shown
pe *a*, from 3 feet to 3 feet
diameter (shown in section
nicates at both ends with
ry, there are screwed from
ubes, $\frac{1}{2}$ an inch wide and
with stopcocks and carry
nd $\frac{5}{8}$ of an inch in diameter,
inary bat's wing burners (each consuming from 3 to 4

cubic feet of gas per hour, for a full luminous effect) upon which are fixed a corresponding number of clay burners. These clay burners *d d d d*, have the dimension above stated, excepting the middle one, which is only 1⅞ inches high and has 70 o 80 perforations. It serves as a support for the combustion-tube *f*, which is thu bedded in a channel of heated fire-clay. The system of brackets lying side by side, acquires sufficient stability by a strong iron frame *g g*, which rests upon two firm supports *h h*, of cast-iron, fastened down by screws upon the foot-plate, *i i*, likewis of cast-iron. The iron frame *g g*, has moreover a groove for the reception o moveable side plates of fire-clay *k k*. They are of the same height as the high burners, over which they project about ⅝ of an inch, in consequence of their resting upon the frame *g*; lastly, *l l* are covering plates, likewise of fire-clay, which are supporte by the side plates *k k*.

The whole disposition of this apparatus will be best understood by the perspectiv view given in *fig*. 18. In the front part, contiguous to the potash-apparatus, the side plates and the covering plates are omitted, in order to show the disposition of the burners. During the combustion, however, all the burners are inclosed, as exhibited in the posterior part of the apparatus.

Fig. 18.



The efficiency of the furnace depends essentially upon the correct disposition of the gas jets. The most appropriate space between the several burners, is about ¼ inch. It is very important for the attainment of a perfectly uniform temperatur that the several brackets bearing the burners should be equidistant. Their position is therefore specially secured by every bracket being fixed in an aperture formed in the iron frame *gg*, *fig*. 17.

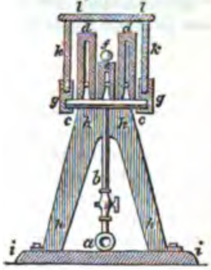
According to the length of the combustion-tube, from 8 to 10 stopcocks (under all circumstances the largest possible number) are opened at once at the commencement of a combustion. If care has been taken to regulate the amount of gas, either by the stopcocks in the horizontal gas pipe, or by those in the separate supply-tubes, the lighted portion of the furnace will, in 10 or 12 minutes, be in a state of perfect incandescence. After this it is only necessary to open the remainder of the stopcocks, in appropriate succession, to insure a slow and regularly progressing combustion. The time required for the completion of an analysis varies from 40 minutes to an hour, rarely more.

The heat obtained by this furnace is very regular; and since it is conveyed to the combustion-tube chiefly by radiation from the incandescent mass of surrounding clay every part of the tube is equally heated. The temperature which it is capable of yielding *is entirely* at the command of the operator. When strained to its full power, it gives a heat equal to that of the strongest charcoal combustion-furnace; but by properly adjusting the stopcocks, it may be kept at any desired temperature, especially since it is only necessary to look into the channel, when, with a little practice, a correct idea of the temperature is rapidly obained from the colour of the glowing cylinders. It deserves, however, to be noticed that the apparatus furnishes rather more heat than is generally required; it is preferable, therefore, under all circumstances, to protect the combustion-tube by a metallic shield: for this purpose ordinary brass wire gauze may be conveniently employed; it is more easily manipulated, and may be used longer than the thin copper or brass plate generally employed.

One great advantage of this furnace is its durability. The clay plates and burners show but little tendency to split, and the mixture of gas and air is so perfect that

er become stopped up with carbon. Moreover, the cost of
ich less than that of the charcoal required to produce the
t. Dr. Hofmann has found that
and requiring the whole length
rners), consumes from 80 to 90
on determination, with 24 rows
lasts about 40 minutes, from
ired, and for a nitrogen deter-
. In laboratories where many
saving of fuel soon covers the

Fig. 19.



ratus and the consumption of
by reducing the number of
3, as shown in *fig.* 19. The
e is of course not so great as
e, but it is sufficient for nearly

s furnace for organic analysis
ne of these invented by Babo, which is much used in the
esented in *fig.* 26, page 235.

ION OF THE SUBSTANCE FOR ANALYSIS.

rmine the proportion of the elements in an organic com-
ure that the substance is in a perfectly pure and definite
hat the processes of ultimate analysis can be advan-
x organic mixtures; only indeed when the proportion of
etermined for commercial purposes, as in the valuation of
s by the quantity of nitrogen which they contain.
egularity of structure, whether crystalline or otherwise, is
of purity: in such cases, examination by the microscope
Constancy of melting-point is also a test of the purity of
of fatty bodies. The purification of solids is generally
from solution, or from the fused state, or in the case of
ion. In liquids, the chief test of purity is constancy of
n is effected chiefly by fractional distillation. In all cases
tance must be burnt upon platinum foil, in order to ascer-
inorganic matter; if the organic body is pure, it will burn
ic matter is present in considerable quantity, or if it forms
ound, as in the salts of organic acids, its quantity must be
ng a weighed portion of the compound.
efore proceeding to the process of combustion, to free the
water. For this purpose, a weighed quantity of the sub-
e in a water-bath at 100°, and then weighed again; if it
heated and again weighed: and these operations are re-
eighings, between which the substance has been heated,
substance may then be considered dry.
a temperature of 100° C. without decomposition, may be
large dish containing strong sulphuric acid, and covering
h a bell-jar; the desiccation is greatly accelerated by
on the plate of the air-pump, and exhausting the air.
e applied to determine the amount of chemically combined
compounds, the water of crystallisation of salts, for ex-
ever, retain their water with too great force to be over-
tioned. Such substances may be dehydrated by enclosing
sed in a water or oil-bath, while a current of dry air is
neans of an aspirator. In some cases even this is not suffi-
an only be effected by heating the substance in a tube
sted by an air-pump, then introducing dry air, exhaust-
substance ceases to lose weight. (See EVAPORATION and

ult to determine how much of the oxygen and hydrogen
ts in the form of water: for many substances, before they
n be eliminated by the methods above described, begin to
npounds. In such cases, the process of organic analysis
pound in the hydrated state, and the quantity of water
ble by the phenomena which the substance exhibits when
actions.

Volatile liquids are dehydrated by leaving them for some time in contact with lumps of fused chloride of calcium and then distilling, the chloride of calcium being however previously removed, as it might, when heated, give up some of the water which it has absorbed.

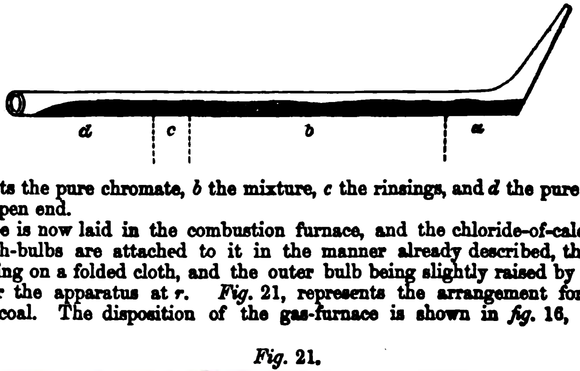
The substance having been brought to the proper state of purity and dryness, may now be subjected to the combustion process.

Estimation of Carbon and Hydrogen.

In Solids not containing Nitrogen.—The substance being thoroughly dry and in the state of fine powder, about 0·3 grm. (or 5 grains) is weighed out in a small test-tube, or between two watch-glasses, the weighing being made exact to the tenth of a milligramme (or ·001 of a grain). The vessel and its contents are weighed together, and after the substance has been removed, the vessel, with the small quantity of matter adhering to it is again weighed. This weight deducted from the former gives the quantity of substance used in the experiment. The combustion-tube after being cleansed, if necessary, is made very hot in the sand-bath, and a long glass tube being thrust into it, the air is sucked out so as to remove every trace of moisture.

The combustion may be made either with oxide of copper or with chromate of lead; the latter being the more easily managed, on account of its possessing little or no hygroscopic tendencies, we shall describe its use in the first place:—A quantity of the chromate (previously fused and pulverised) sufficient to fill the tube, is heated over a gas lamp till its colour changes to brown-red. When it has cooled, a small quantity is poured into the tube, sufficient to fill about an inch of its length, and about two-thirds of the remainder is poured into a clean dry porcelain mortar. The substance to be analysed is then added to it, and the two are carefully mixed by gentle trituration. The combustion-tube being then taken in the right hand, and the mortar in the left, the mixture is transferred to the tube by a kind of screwing motion, the open end of the tube being slightly inclined upwards after each addition, and the tube lightly tapped against the side of the mortar to make the mixture descend. When nearly the whole of the mixture has been thus introduced, a small quantity of fresh chromate is poured into the mortar, triturated so as to rinse it, and then transferred to the tube in the same manner. The remainder of the tube up to within an inch of the end is filled with pure chromate. The contents of the tube are then shaken together by a few gentle taps on the table, so as to leave a free passage throughout for the evolved gas. The arrangement of the mixture in the tube is shown in *fig.* 20, where

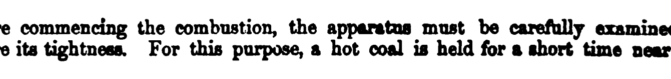
Fig. 20.



a represents the pure chromate, *b* the mixture, *c* the rinsings, and *d* the pure chromate near the open end.

The tube is now laid in the combustion furnace, and the chloride-of-calcium tube and potash-bulbs are attached to it in the manner already described, the potash-bulbs resting on a folded cloth, and the outer bulb being slightly raised by placing a cork under the apparatus at *r*. *Fig.* 21, represents the arrangement for burning with charcoal. The disposition of the gas-furnace is shown in *fig.* 16, page 225.

Fig. 21.

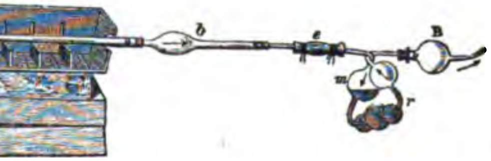


Before commencing the combustion, the apparatus must be carefully examined to ensure its tightness. For this purpose, a hot coal is held for a short time near the

pparatus, so as to rarefy the air and cause a few bubbles
he coal is then withdrawn, and the apparatus left to
If all the joints are air-tight, the liquid will now rise
el than in the outer-bulb, and will retain its position;
oon fall down to its original level. Should this be the
ably in the cork which fits into the combustion-tube, or
To remedy this inconvenience without delay, it is well
hree well dried perforated corks and a good stock of

ratus having been established, the heat may now be
n of the tube containing the pure chromate is first
d-hot charcoal round it (or turning on the gas jets im-
arcoal furnace is provided with a moveable screen *g*,
from extending too quickly along the tube. When the
red-hot, the pure chromate of lead at the closed end of
o redness, in order to burn any vapour that may diffuse
nd to prevent its deposition on the drawn out point,
e difficult to remove (this precaution must be taken in
process). The fire is slowly extended towards the fur-
f the mixture being thoroughly burnt before the fire is
stion should be so regulated that the carbonic acid may
iform rate, and in a succession of bubbles which may be
en is present, these bubbles are, after a certain time,
otash; but when an azotised body is burnt, bubbles of
sh-solution during the whole process.
ated to redness throughout, the heat must be raised by
admitting air below by slightly raising the furnace from
volution of gas begins to slacken, the cork is removed
nd the apparatus brought into the horizontal position.
well, the evolution of carbonic acid ceases all at once;
bbles continue to pass slowly at intervals for a long time
ughly ignited, we may be sure that the combustion is
nsequence of the mixture not having been sufficiently
of carbon will be found deficient.
f gas ceases, the liquid begins to rise in the bulb *m*.
kly removed from the end of the tube, and the point
rs. If the passage through the tube is clear; the potash-
he same level in both bulbs: if it does not, there is a
ime must be lost in clearing it, by thrusting in a stout
therwise the potash-solution will be sucked up into the
the result will be entirely destroyed. To complete the
essary to draw a stream of air through the apparatus, by
13) to the extremity *p*, of the potash apparatus, so as to
rbonic acid and aqueous vapour remaining in the tube
be and potash-bulbs. In doing this, however, a certain
he broken end of the tube being surrounded with an
portion of this gas is likely to be drawn through the

Fig. 22.



, thereby making the proportion of carbon appear too
g glass tube open at both ends is placed over the end of

the combustion-tube, and supported in a slanting position, as in *fig.* 22, while the ai is being drawn through the apparatus. By this means, the air is drawn from a heigh above the stratum of carbonic acid over the furnace. When the gas furnace is use this precaution is of course superfluous, as the flame can be extinguished at once.

Lastly, the chloride-of-calcium tube and the potash-bulbs are detached, left to coo for about half an hour, and then weighed. The increase of weight of the potash-bulb gives the quantity of carbonic acid produced, and $\frac{3}{11}$ of this is the quantity of carbo in the substance analysed. The increase of weight of the chloride-of-calcium tub gives the quantity of water produced, and $\frac{1}{9}$ of this is the amount of hydrogen. Know ing then the quantities of carbon and hydrogen in a given quantity of the substanc analysed, it is easy to calculate the proportions of carbon and hydrogen in 100 part If the quantities thus determined make up 100, the substance is a hydrocarbon ; there is a deficiency, and it is known that no nitrogen, sulphur, chlorine &c. is presen the difference gives the percentage of oxygen. Examples of the calculation will b given further on.

Combustion with Oxide of Copper. — When the combustion is made with oxide copper instead of chromate of lead, particular precautions are required to prevent th absorption of water during the mixing and filling of the tube. A quantity of th oxide is heated to redness in a covered earthen crucible, and left to cool till it wi no longer burn a cloth in which the crucible is held. It is then mixed in a hot morta with the substance to be analysed, and the mixture is arranged in the tube betwee two columns of pure oxide of copper, exactly as described for chromate of lead, th whole operation being conducted as quickly as possible. Some substances, howeve will not bear mixing with hot oxide of copper; and even when this can be done, th oxide is sure to cool during the mixing sufficiently to cause an absorption of moistur from the air: hence an excess of hydrogen in the result of the analysis. To obviat this source of error, it is sometimes recommended to lay the tube, after filling, in trough of hot sand, and connect it with an air-pump, then introduce air dried by pas ing over chloride of calcium, exhaust again, and so on. This, however, is a trouble some complication of the process. A simpler method of preventing the absorption water, is to pour the oxide of copper, while still hot, into a long-necked flask (*fig.* 23 closed by a perforated cork in which a chloride-of-calcium tube is inserted, leav it to cool, and mix it with the organic substance in the combustion-tube itsel The neck of the flask must be a little wider than the combustion-tube, so tha the latter will just pass into it (*fig.* 24): the oxide may then be transferred to th tube without coming in contact with the air. A small quantity of the cooled oxid is first introduced in this manner, then a portion of the organic substance is added and upon this a column of oxide about three inches long is poured in the sam manner as before. This portion of oxide is mixed with the organic substance b stirring it with a clean iron rod (*fig.* 25), the extremity of which is bent into tw turns of a screw; and when it is thoroughly incorporated, the rest of the substance i introduced, then another column of oxide of the same length as before, and the stirrin is repeated. Lastly, the rest of the tube is filled with pure oxide, and the combustio performed as above. This method of incorporation does not ensure so complete a mix ture of the substance with the oxide as trituration in a mortar; but it answers thi purpose sufficiently well in most cases.

Fig. 23.

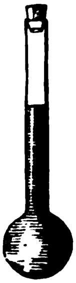


Fig. 24.

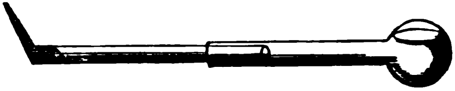
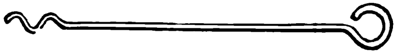


Fig. 25.



Oxide of copper is in many respects more convenient for use than chromate of lead and indeed is more generally used for the combustion of substances which burn with facility. It is more easily prepared, and when partially reduced by the combustion process, may be restored to its original state by moistening it with nitric acid, an crucible. It then becomes denser and less hygroscopic, ed for use: in fact, it improves in this respect by each Chromate of lead may also be reoxidised by digestion nt fusion; but the pulverisation of the fused mass is a

are many cases in which the use of chromate of lead iz. in the combustion of substances which are very rich such as fatty bodies, coal, graphite, indigo, &c. Such rned by oxide of copper, probably because, at the begingive off combustible gases, which partially reduce the f each particle, and leave behind a quantity of charcoal oxide, and requiring an atmosphere of free oxygen to ad fuses when the heat becomes strong, thus becoming the combustible substance, and moreover gives off a h effectually completes the combustion of the carbon. her increased by mixing it with about $\frac{1}{10}$ of its weight

tates, &c.) of potassium, sodium, barium, strontium, or copper, also exhibit a considerable deficiency of carbon, s in the form of a carbonate. This source of error may oxide of copper a quantity of phosphate of copper or o decompose the carbonate; or, better, by making the ead.

opper in a stream of Oxygen. — The oxygen may either potassium placed in the combustion-tube, or in a vessel be previously prepared and supplied from a gas-holder

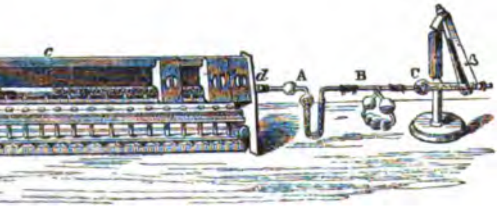
ling is to place at the closed end of the combustion-tube 1 pt. of chlorate of potassium (or better of perchlorate) reviously heated over a lamp and introduced while hot; ide of copper, then the mixture, and a column of pure ion is carried on in the ordinary manner, until the tube xide near the sealed end. Heat is then cautiously applied chlorate, so as to evolve oxygen at a moderate rate. etely burned, and if the supply of oxygen is sufficient, ed. After the gas has passed through the potash-solut being perceptibly absorbed, the bulbs and the chlorideed, without breaking off the point of the combustion-tube, to displace the free oxygen, which would otherwise in-

n passing through the potash-solution is sure to carry pour of water. To prevent this, a small tube containing d be attached to the bulb apparatus. The apparatus ighs between 50 and 60 grammes.

above described, there is, however, considerable danger ning too rapid, and thereby carrying off the vapour faster e solid potash.

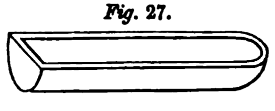
supply the oxygen from a gas-holder. The combustion-

Fig. 26.



d the end *a*, furthest from the potash-bulbs and chloridewith two gas-holders (*fig.* 26), one filled with atmospheric air, and the other with oxygen gas. The communication is made by means of a T-tube provided with a cock, which renders it easy to connect either gas-holder with the combustion-tube and shut off the other at the same time. The air and oxygen before entering the combustion-tube, are made to pass through two U-tubes, one containing pumice-stone soaked in sulphuric acid, to dry the gas, the other lumps of caustic potash, to free it from carbonic acid. The combustion-tube may be heated either with gas or with charcoal (the figure represents a Babo's gas apparatus), and the mixture may be disposed in the tube in the ordinary way. But instead of mixing the substance with the oxide of copper, it is better in many cases to place it by itself in a small boat of platinum or porcelain *b* (*fig*. 27).

Fig. 27.



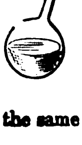
The combustion-tube is first filled to two-thirds of its length with oxide of copper, which need not be previously ignited, the remaining third, nearest to the gas-holder being left free to receive the boat. It is then laid in the furnace, and connected, in the manner just described, with the gas-holder containing atmospheric air; the oxide of copper is heated to redness; and a stream of dry air is passed through the tube so as to remove every trace of moisture. The tube is then left to cool; the boat containing the substance is put into its place, a plug of recently ignited asbestos having been previously introduced to prevent the oxide of copper from coming in contact with it; the chloride-of-calcium tube (U-shaped, see p. 228) and potash-bulbs are attached in the usual manner, and the apparatus is connected with the gas-holder containing oxygen. The oxide of copper is now once more heated to redness, and as soon as it is thoroughly ignited, heat is very cautiously applied to the part of the tube containing the boat, a slow stream of oxygen being passed through the apparatus, sufficient to prevent any backward passage of the evolved gases, but not to cause any free oxygen to pass through the solution of potash. If the oxide of copper exhibits a red colour, arising from reduction, the heating of the substance in the boat must be discontinued till the copper is reoxidised. When at length there is nothing left of the substance but black charcoal, the heat may be increased and the stream of oxygen accelerated. In this manner the combustion is soon completed; and when the bubbles of gas appear to pass through the potash without absorption, the process is continued in the same manner for a few minutes longer, and the potash-bulbs and chloride-of-calcium tube are then detached, after air has been passed through the apparatus for a little while to expel the oxygen. Lastly, the stream of air is continued for a sufficient time to effect the complete reoxidation of the copper, which is then ready for another experiment without further preparation.

After the tube has cooled, the boat is taken out and reweighed. If any inorganic matter remains in it, the quantity of this is at once ascertained if the weight of the boat itself is previously known.

This method, when carefully conducted, gives very exact results: it ensures the complete combustion of the carbon, and obviates all danger of an excess of hydrogen arising from moisture in the oxide of copper. It likewise saves the trouble of igniting the oxide of copper before the experiment, and afterwards treating it with nitric acid, But to ensure a good result, especial care must be taken not to heat the substance in the boat too suddenly; otherwise combustible gases will be given off more quickly than they can be burnt, and the analysis will be worthless.

Combustion of Liquids.—Volatile liquids are enclosed in small glass bulbs with narrow necks (*fig*. 28). The bulb is first weighed and then filled with the liquid, in the same manner as a thermometer tube, viz. by gently warming the bulb so as to rarefy the air, and dipping the neck into the liquid, so that as the air cools, a small quantity of the liquid may be forced up by external pressure. The bulb is then again heated till the liquid boils, the end of the neck immediately plunged again into the liquid, and the heat removed. The vapour now condenses and leaves a vacuum, into which the liquid is forced up so as to fill the bulb and the greater part of the neck. The neck is then sealed, and the bulb re-weighed. It is best to use two bulbs, each containing about 400 milligrammes of liquid.

Fig. 28.

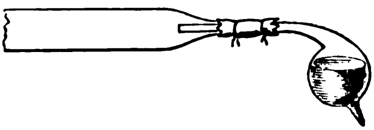


The analysis is made with oxide of copper: the coarse-grained variety obtained by oxidising copper turnings in a muffle, or by breaking oxide which has been hardened by strong ignition into small lumps, and sifting off the finer particles, is best adapted for the purpose, because it affords free space for the passage of the vapours, whereas the fine-grained oxide lies more compactly, and the greater part of the vapour passes over the surface instead of finding its way between the particles. For the same reason, chromate of lead, which fuses into a mass, is not so well adapted for

ls. The oxide of copper must be ignited in a crucible
corked flask (p. 234).
be at least 20 inches long, very volatile liquids
. About an inch of the cold oxide is first poured in
one of the bulbs is then taken by the neck, a slight
nade on it with a file; it is thrust into the tube, bulb
at the scratch, and both bulb and neck dropt into the
oxide is then added, the other bulb introduced in the
l up with oxide of copper. This oxide is first heated
proceed very gradually, and when the charcoal furnace
a screen. As soon as the oxide is well ignited, a hot
rest bulb, so as to volatilise a portion of the liquid,
drive it over too fast. When the first bulb is empty,
the liquid in the second bulb is then distilled in the
ion is finished in the ordinary way. As soon as the
ices, a few pieces of hot charcoal must be placed under
e, to prevent the liquid from condensing there, as if
vill be required to dislodge the liquid, and a sudden
place.
bs is to prevent too great a reduction of copper in the
; when there is no longer any oxide close to the bulbs,
o take place, and then a stream of air or oxygen is
Williams, however, uses only one bulb, and drives all
ement of the analysis, into a column of cold oxide of
This portion is not directly heated till the end of the
ilised by the heat conducted by the oxide. Finally, a
gh the tube to burn the deposited charcoal. Volatile
ntinuous stream of oxygen, because an explosive mix-

s, like aldehyde, a different plan is adopted. Such
having the form of a small retort, the neck of which,
into the
stion-tube,
en for the
made air-
tube. As
nited, the
ken off by
stion-tube,
cautiously
of tepid water to the bulb. If the liquid is so volatile
the room, the bulb must be immersed in ice, and the
ng the ice from time to time, and replacing it as soon

Fig. 29.



short test-tube, which is then dropped into the com-
of oxide of copper having been first introduced,—and
made to spread itself over the sides for about half the
filled up with oxide of copper or chromate of lead.
ed in the same manner. Waxy bodies are weighed in
the combustion-tube, and spread over its surface by
may also be placed in boats in the manner already
h chromate of lead, or with oxide of copper in a stream

bustion-process in particular Cases:
ogen.—When an azotised organic body is burnt, the
given off in the free state, together with the water
ain portion, varying according to the nature of the
ich the combustion takes place, is converted into nitric
es of nitrogen. Now, if either of these compounds is
analysis, it will pass over with the carbonic acid, and
aches the potash-ley, it will be absorbed by that liquid
estimation of the carbon. Before, therefore, an organic
combustion process, it must be carefully examined for
described (p. 226), and if that element is found to be
e made in such a manner as to ensure that the whole
e state.

For this purpose a long combustion-tube is taken, and after the mixture and th pure oxide of copper have been introduced in the ordinary way, about five inches copper-turnings, prepared as described at p. 227, are placed at the open extremit This metallic copper must be heated in a sand or air-bath just before it is wante and introduced into the tube while still hot, as its surface is very hygroscopi The combustion is made in the ordinary way, the metallic copper being however fir heated to redness, and kept in a state of strong ignition during the whole proces The nitrogen is then evolved in the free state, and passes through the potash-ley i bubbles.

The combustion must be made with oxide of copper alone: if chromate of lead used, or a continuous stream of oxygen passed through the tube, the quantity of nitr oxide formed is too large to be effectually decomposed, even by a very long column red-hot copper. Oxygen may, however, be passed through the tube at the end of th combustion, being evolved for that purpose from chlorate of potassium (p. 235). Th more slowly the combustion is conducted, the smaller will be the quantity of nitr oxide formed.

β. *In bodies containing Sulphur.*—When organic bodies containing sulphur a burned with oxide of copper, the sulphur is converted into sulphurous acid, which, not intercepted, will pass into the potash-solution together with the carbonic aci This may be prevented, by interposing between the chloride-of-calcium and potasl apparatus, a tube containing peroxide of lead: the sulphur will then be retained i the form of sulphate of lead. It is better however to make the combustion wit chromate of lead, placing in the front part of the tube a rather long column of pu chromate, which is heated only to dull redness: the sulphur will then be retained in th combustion-tube.

γ. *In bodies containing Chlorine.*—When chlorinated organic compounds are burn with oxide of copper, chloride of copper is formed, which being volatile, passes ove into the chloride of calcium tube, and renders the determination of the hydroge inexact. This source of error may be completely avoided by burning with chroma of lead, the chlorine then forming chloride of lead, which is not volatile even at a re heat.

Similarly with bodies containing *bromine* and *iodine*.

δ. *In bodies containing Inorganic Matter.*—If an organic body, when burnt in th air, leaves a residue which gives off carbonic acid on being treated with acids, i analysis by combustion with oxide of copper will not give exact results, because a pa of the carbonic acid will be retained in the ash, instead of passing into the potash-bulb This is particularly the case with the organic salts of potassium, sodium, barium strontium, and calcium. If the residue were in all cases a neutral carbonate, i quantity might be determined and the amount of carbonic acid contained in it adde to that which is absorbed in the potash apparatus. But this is not the case, th composition of the residue being variable, and depending on a variety of circumstance

In such cases, the complete evolution of carbonic acid may be ensured in two ways either by burning with oxide of copper, and mixing the organic substances with ignite phosphate of copper, boric anhydride, or oxide of antimony; or better, by burning wit chromate of lead, the alkaline carbonate being then completely decomposed by th chromic acid.—When these organic salts are burnt in a platinum boat, in a stream oxygen (p. 231), the residue may be weighed, the quantity of carbonic acid in determined in the ordinary way, and added to that absorbed by the potash.

Amount of Error in the Estimation of Carbon and Hydrogen.—By th methods above described, the carbon may be determined within 0·2 per cent. Th error is generally in defect, in consequence of imperfect combustion; sometimes, however, it is in excess, especially in azotised bodies.

The hydrogen may be determined yet more nearly, viz. within 0·1 per cent. Th error is usually in excess, arising from absorption of water from the air during th mixing of the substance with oxide of copper. But if this be avoided, by making th mixture in the tube itself, or if the combustion be made with chromate of lead, onl a very slight excess of hydrogen need be apprehended. When the substance is burn in the platinum boat (p. 231), the hydrogen sometimes comes out a little below th theoretical quantity.

ESTIMATION OF OXYGEN.

Oxygen is usually estimated by difference, after all the other elements of the compound have been determined directly. In compounds containing only carbon, hydrogen, and oxygen, this method is sufficiently accurate: for, the error of the carbon bein generally in defect, and that of the hydrogen in excess, the two nearly compensat each other; but when chlorine, sulphur, and other elements are present, the error

the same direction, viz. in defect, the amount of oxygen
ly to be much too great. A good method of determining
lesideratum, more especially as it would afford a check
elements.

determination has been given by **Baumhauer** (Ann.
ied in one or two cases. A combustion-tube open at
dinary way for the determination of carbon and hydro-
pparatus are placed in connection with graduated glass
tremity of the combustion-tube being filled with oxygen,
is finished, a stream of oxygen may be passed through
educed copper. The apparatus is then left to cool, the
s is read off, and compared with the quantity before the
paid to corrections for temperature and pressure. The
f oxygen taken up by the reduced copper. Now, the
nd water produced by the combustion having been
gen in this carbonic acid and water, diminished by the
disappeared, gives the quantity of oxygen contained in
f the amount of oxygen in the carbonic acid and water
oxygen absorbed by the copper were 7, the amount of
nce would be 3.

ses (of oxalic acid and oxalate of lead), in which the
s method with great exactness. As, however, the total
(the combustion-tube, potash-bulbs, &c.) is not known,
me before and after the experiment, the corrections for
not be made with accuracy. For exact results, it is
essure and temperature at the beginning and end of the
e same.

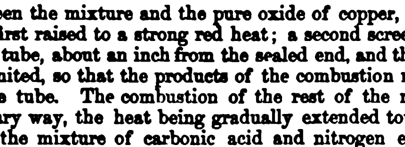
STIMATION OF NITROGEN.

an organic compound is determined, either by burning
pper and metallic copper in the manner already described,
f nitrogen evolved,—or by igniting the compound with
en is evolved in the form of ammonia, absorbing the
and precipitating by dichloride of platinum.

d in the free state, it may be estimated in two ways, viz.
parison with the quantity of carbon in the compound,
solutely, that is, by direct measurement of the whole

d.—A mixture of the substance (which need not be
rtion of oxide of copper, is introduced into a combustion-
half filled by it, the remainder of the tube being filled

Fig. 30.



r, half with copper turnings. To the mouth of the
s-delivery tube, which passes into a trough of mercury
sertion of a tube of caoutchouc.

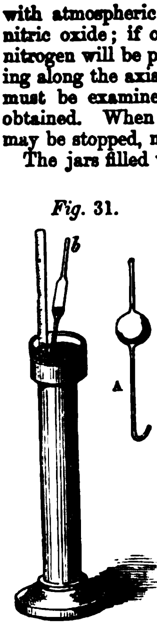
en the mixture and the pure oxide of copper, the oxide
irst raised to a strong red heat; a second screen is then
tube, about an inch from the sealed end, and the portion
nited, so that the products of the combustion may drive
e tube. The combustion of the rest of the mixture is
ry way, the heat being gradually extended towards the
the mixture of carbonic acid and nitrogen evolved is
duated jars, half an inch in diameter, and twelve or
jars must be accurately divided into equal parts of the
olute value of the divisions may be any whatever.

is about three-fourths filled with gas, it should be lifted
ry allowed to run out, so that its place may be supplied

with atmospheric air. The object of this is to ascertain whether the gas is free fro nitric oxide; if only $\frac{1}{1000}$ pt. of that gas is present, reddish fumes of peroxide nitrogen will be produced, and if not seen immediately, will become visible on looking along the axis of the tube. If any red or yellow colour is perceptible, another ja must be examined in the same manner, and so on till perfectly colourless gas obtained. When about six jars have been filled with the gaseous mixture, the proce may be stopped, nothing being gained by carrying it to the end.

The jars filled with gas are now to be transferred one by one to a tall jar (*fig.* 31 containing mercury, and the proportion of carbonic acid and nitr gen in each of them determined, by first bringing the mercury the same level inside and out, and reading off the volume of th gaseous mixture, then absorbing the carbonic acid by a stron solution of caustic potash, introduced by means of the curve pipette A, and reading off the volume of nitrogen left. If th combustion has been properly conducted, the proportion of ca bonic acid and nitrogen should be the same in all the jars.

Fig. 31.



Now, a molecule of anhydrous carbonic acid CO^2, containing 1 ato of carbon [= 12], occupies the same volume as a molecule (or doub atom) of nitrogen, NN [2 . 14 = 28]. If therefore, the volumes carbonic acid and nitrogen in the gaseous mixture are to o another as $m : 1$, it follows that the number of carbon-atoms to the number of nitrogen-atoms as $m : 2$, and consequently th weight of the carbon in the compound is to that of the nitrogen $m \times 12 : 2 \times 14$, or as $3\,m : 7$; so that, if the percentage carbon (c) be previously found, the percentage of nitrogen (n) will l given by the equation:

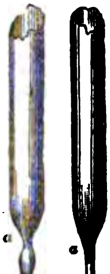
$$n = \frac{7}{3\,m}\,c.$$

For example, caffeine, which contains 49·48 per cent. of carbon, found by the process just described to yield carbonic acid an nitrogen in the proportion by volume of 4 : 1; the percentage nitrogen in caffeine is therefore $\frac{7}{3 \times 4} \,.\, 49{\cdot}48 = 28{\cdot}89$.

This comparative method of estimation yields perfectly satisfactory results for a compounds in which the proportion of nitrogen to carbon is not less than 1 : 8, pr vided the combustion is conducted in such a manner as to avoid the evolution of nitr oxide. The risk of error from this source is less, *the more intimately the organic su stance is mixed with the oxide of copper, and the more slowly the combustion is pe formed.* This rule applies to all combustions of azotised bodies.

Liebig's comparative method has been variously modified by different chemist Bunsen has contrived a form of apparatus by which it may be carried out wit accuracy, even when the proportion of nitrogen is very small, and with not mor than a few centigrammes of substance. This method consists in burning the sul stance with oxide of copper and metallic copper in a sealed tube fille with hydrogen, and analysing the resulting mixture of carbonic acid an nitrogen in a carefully graduated eudiometer.

Fig. 32.

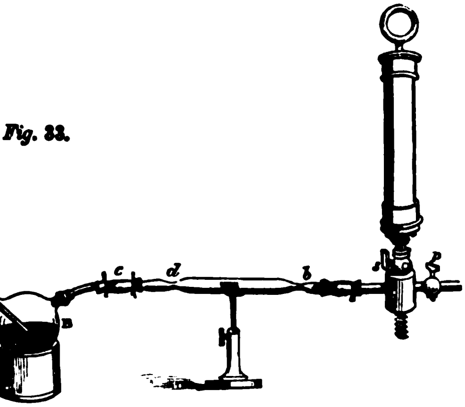


A tube of thick Bohemian glass, about 15 inches long, and $\frac{3}{4}$ of a inch internal diameter, is drawn out at one end in the form of a con as shown at *a* (*fig.* 32), and the part *a* is then heated in the blowpip flame till it is contracted and the glass very much thickened. A mi ture of 3 to 5 centigrammes of the organic substance, with 5 grms. oxide of copper, is now introduced into the tube, together with a fe copper turnings, and the other end of the tube is drawn out and thickene in the same manner as the first. The tube is then connected at one en with a hydrogen-apparatus, *fig.* 33 (A being the generating vessel, an B a receiver containing sulphuric acid to dry the gas), and at the othe with an exhausting syringe. The hydrogen, after passing through th tube, escapes by the cock *p*.

As soon as all the air is expelled, the cock *p* is closed, the cork of th generating vessel loosened, the caoutchouc tube *c* tightly tied, the tul partially exhausted by a stroke of the pump, and the cock *s* immediately closed. Th tube is now sealed at *d* and *b* with the blowpipe flame, the sealing being much facilitate by the partial exhaustion. The next step of the process is to heat the tube to rednes having first enclosed it in a mould of gypsum, to prevent it from being blown out h the expansion of the enclosed gases. For this purpose, the two halves of a cylin drical mould of iron plate, shown in *fig.* 34, are filled with gypsum paste mixe

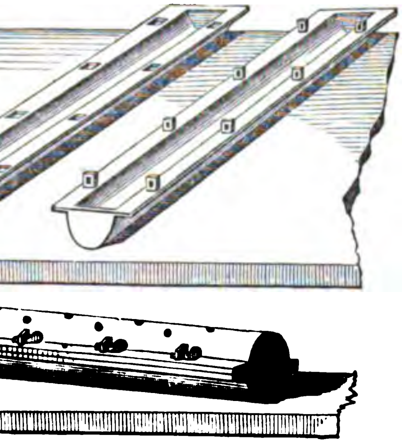
as soon as the plaster begins to set, the tube is laid
the other half put on, and the two firmly wedged
then heated to low redness for an hour, the tube taken
of the sealed ends broken off under a graduated jar full

Fig. 33.



re of carbonic acid and nitrogen in the tube may pass up
gaseous mixture is moistened by passing up a drop of
ured, with due regard to corrections for pressure and
freed from carbonic acid by thrusting up into it a ball of

Fig. 34.



of an iron wire (see ANALYSIS OF GASES), the ball being
on it. This ball is then withdrawn, and another ball of
e purpose of drying the gas, after which the residual
oportion of carbon and nitrogen is then calculated in the

big's method have been introduced by Dr. **Maxwell**
. vi. 290), by **Marchand** (J. pr. Chem. xl. 177) and
m. lxxxviii. 241).

ganic compound is burnt with oxide of copper, as before,
bonic acid and nitrogen collected. In the form originally
big, the carbonic acid and nitrogen were collected in a
and standing over mercury, the gas-delivery tube being
the mercury into the air in the jar. The volume of air

was carefully noted before the experiment, also the volume of air and gas when the combustion was finished and the apparatus had been left to cool, the observed volumes being in each case reduced to the standard pressure and temperature; the increase gave the volume of carbonic acid and nitrogen produced by the combustion. The volume of carbonic acid was then calculated from a previous determination of the carbon, and this, deducted from the volume of the mixed gases, gave the quantity of nitrogen by volume, from which the weight was calculated. For example, 0·1 grm. caffeine burnt in this manner yields 114·06 cub. cent. of gas at 0° C. and 28" bar. The same quantity burnt in the ordinary way yields 0·181 grm. carbonic acid, corresponding to 91·09 cub. cent. at 0° C. and 28 inches of the barometer: consequently 0·1 grm. caffeine yields 114·06 – 91·09 = 22·85 cub. cent. nitrogen gas = 28·86 per cent. by weight.

The process in this form is liable to numerous sources of error. In the first place, the necessary limits to the the size of gas jars standing over mercury, restricts the quantity of substance burnt to 1 or 2 decigrammes; and with this small quantity the errors of observation and manipulation bear too great a proportion to the whole to give even a good approximation to the truth, unless the proportion of nitrogen is rather large. Very considerable errors may arise from the alteration in the dimensions of the tube, likely to result from softening by heat, and from the consumption of a portion of the oxygen of the air in the tube during the combustion. (*For the details of the process*, see *Handwörterbuch d. Chemie*, 2te Aufl. i. 873.)

To remove these sources of error, the process has been modified by Dumas and others, so as to make the result independent of the volume of air in the apparatus. This is effected by replacing the air by another gas, which can afterwards be removed by absorption, and sometimes also by exhausting with the air-pump.

In Dumas's process, the air is removed from the combustion-tube, partly by exhaustion with the air-pump, and partly by a stream of carbonic acid gas evolved from carbonate of copper placed at the sealed end of the tube. The combustion is then performed; the carbonic acid and nitrogen evolved by it are collected in a graduated jar standing over mercury, and containing also solution of potash, which absorbs the carbonic acid; and, when the combustion is finished, the carbonate of copper is again heated, so as to evolve carbonic acid, and sweep all the remaining nitrogen into the jar. The volume of nitrogen is then observed, with due regard to pressure and temperature.

This process gives accurate results; but it is troublesome, and requires rather complicated apparatus. A simpler form of it is now generally used, in which the exhaustion with the air-pump is dispensed with by the use of a substance which evolves carbonic acid more abundantly than carbonate of copper. This simplification is due to **Melsens**. (Ann. Ch. Pharm. lx. 115.)

At the sealed end of a combustion-tube 30 inches long, is placed a layer, 6 inches long, of acid carbonate of sodium, *a b* (*fig.* 35); then oxide of copper, *b c*; then the mixture of the organic substance with oxide of copper, *c d*; then strongly ignited oxide of copper, *d e*; and, lastly, copper turnings, *e f*. The tube is enveloped in copper foil or brass wire gauze, and connected by a gas delivery-tube with a graduated jar, standing over mercury (*fig.* 36), and partly filled with strong solution of potash. The tube is laid in the combustion furnace, and the acid carbonate of sodium gradually heated, the other part of the tube being protected by a screen. Carbonic acid gas is then evolved, and drives the air out of the tube. It is tested from time to time by collecting it in small tubes filled with mercury, and passing caustic potash into it. As soon as the gas is completely absorbed by the potash-ley, showing that all the air is expelled from the tube, the heat is removed from the acid carbonate of sodium; the graduated jar, filled partly with mercury, and partly with potash-ley, is adjusted in its place over the extremity of the delivery-tube, and the combustion is commenced. The nitrogen and carbonic acid then pass over together; the carbonic acid is absorbed

Fig. 35.

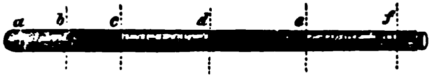
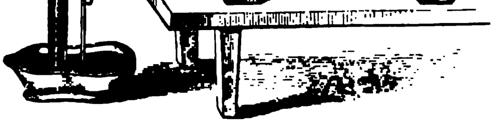


Fig. 36.



en collects in the jar. When the combustion is finished,
id carbonate of sodium, so as to evolve more carbonic acid,
trogen into the gas jar.

er the caustic potash till the absorption of the carbonic
mplete: it may be accelerated by a gentle agitation. A
ced under the jar, pressed against it, to prevent the mer-
ne jar is transferred from the mercury-trough to a large
ng the glass plate, the mercury and potash-ley run out,
y water. The volume of the gas is then read off, and
ure and temperature, allowance being also made for the
. From the corrected volume of nitrogen thus obtained,
by calculation.

of soda is used in this process, it must be tested
ertain whether it gives off any gas not absorbable by
le to subject all the materials used in the process to a
ganic substance. They ought not to yield more than ½ to
potash-ley.

importance, in all nitrogen estimations in which the
lume, to test carefully the accuracy of the weights with
nalysed is weighed out. In other analyses, the absolute
unimportant, provided they agree amongst themselves;
d its subdivisions, with which the substance is weighed
dard values, the weight of the nitrogen, determined by
volume, according to fixed data, will not give the true
in the compound.

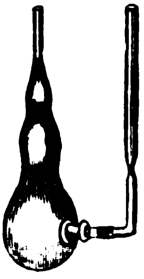
umas's process is given by Dr. **Maxwell Simpson**
The combustion is made with a mixture of oxide of
e free oxygen evolved by the latter being absorbed by
pheric air expelled by a stream of carbonic acid, evolved
e. The gaseous mixture evolved by the combustion is
liar construction, from which, after the carbonic acid has
nitrogen can be transferred, without loss, to a eudio-
ed over mercury. The details are as follows:—

½ to 3 feet long, is sealed at one end, and a mixture of
se and 2 grm. mercuric oxide (the latter being added to
of carbonic oxide) is introduced into it. At an inch
plug of asbestos, and then the mixture of the substance
.) with about 45 times its weight of a mixture of 4 pts.
oxide of mercury. To ensure that the oxide of mer-
must be prepared, not by ignition of the nitrate, but by
nate with excess of caustic potash; the precipitate is
oric acid, to remove free potash, then with water, and

troduced, the mortar is rinsed out with oxide of copper,
al; then a plug of asbestos is thrust in; then 2 or 3
added, this also being kept in its place by an asbestos
up with metallic copper, prepared by
ide (p. 226) with hydrogen. The open
awn out, and the neck joined by a
gas delivery-tube, bent at right angles
trough.

laid in the furnace, and heat is applied
de of copper, and at the same time to
he heated portions being shut off by
tube; and as soon as the air is com-
e by the stream of carbonic acid, the
nce with the oxides is heated in the
kwards, the tube being first connected
eive the nitrogen. This vessel has the
apacity of about 200 cub. cent.: the ex-
part should not exceed 7 or 8 mm.
outchouc, 1½ inch long, is slipped over
ately fit, to the extent of half an inch, and securely
A glass rod, half an inch long, with the ends ground
meter as the caoutchouc tube, is thrust down the latter
A piece of thermometer tubing, also of the same dia-
ir-bore, is bent into the form shown in *fig.* 38, and also

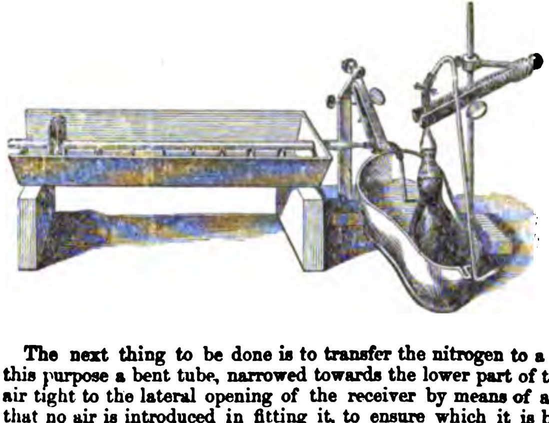
Fig. 37.



inserted. The caoutchouc is next slightly stretched over it, and firmly secured wit silk cord, so that there may be no interval between the glass rod, bent tube, and g vessel. A silk cord is, lastly, tied round the part of the caoutchouc tube where t solid rod lies, so as to make it perfectly air-tight. Before using the apparatus, t joints must be tested by partially filling it with mercury, plunging the mou beneath the surface of the liquid, and observing if the level remains constant.

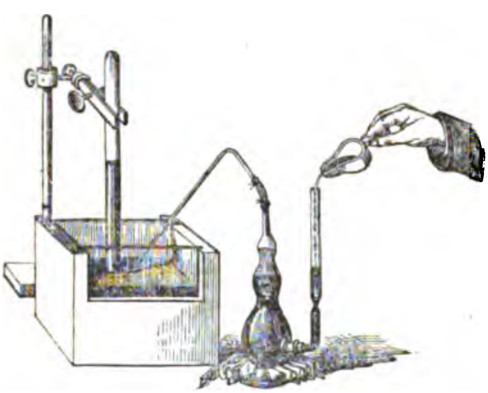
The apparatus is completely filled with mercury and caustic potash solution, a placed in the mercurial trough as shown in *fig.* 38. The gas delivery-tube, proceedi from the combustio tube, being then i serted into its later opening, the produc of combustion pass in it, the carbonic ac being absorbed by t potash-ley, while t nitrogen remains. the termination of t combustion, the nitr gen still remaining the tube is swept o into the receiver by stream of carbonic ac evolved by heating t portion of carbonate manganese still remai ing undecomposed.

Fig. 38.



The next thing to be done is to transfer the nitrogen to a eudiometric tube. F this purpose a bent tube, narrowed towards the lower part of the upright arm is fitt air tight to the lateral opening of the receiver by means of a cork, care being tak that no air is introduced in fitting it, to ensure which it is best to moisten the co with a solution of corrosive sublimate. Mercury is now poured into the bent tub and the receiver is lifted out of the mercury, carried to a mercurial trough with gla sides (*fig.* 39), and allowed to stand for an hour or two, so that the absorption of t carbonic acid may be com plete. A eudiometer, pr viously moistened with a dr of water, so that the gas m be saturated with moistu is then carefully filled wi mercury, and inverted in t trough; the end of the g delivery-tube from the r ceiver is brought under i the cord which tied t caoutchouc tube to the gla rod is removed; and the n trogen is driven into t eudiometer by slowly pouri mercury into the bent tu as shown in the figure. soon as the potash-ley mak its appearance in the gas d livery-tube, the addition mercury is stopped. T volume of nitrogen whi then remains in the gas delivery tube is exactly equal to the volume of the air whi was contained in it at the beginning of the process, and was driven into the eudiomet tube by the first portions of mercury added, so that the volume of gas driven into t eudiometer is exactly that which was contained in the receiver. Lastly, the gas measured, with due regard to pressure and temperature, and the weight calculat accordingly.

Fig. 39.



This process gives very exact results. Its peculiar advantages are, that the fr oxygen evolved from the oxide of mercury ensures complete combustion, while t vapour of mercury prevents the formation of any oxides of nitrogen: moreover, enables the gas to be measured over mercury, which is much more exact than t ordinary mode of measuring over water.

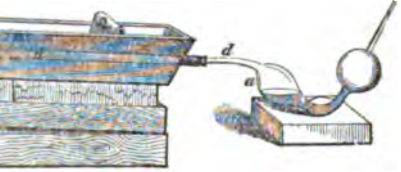
Will and Varrentrapp's Method.—Most azotised organic
potassium or sodium, give off the whole of their nitrogen
carbon uniting with the oxygen of the alkaline hydrate to
hydrogen combines with the nitrogen to form ammonia. If
sent is not sufficient to unite in this manner with all the
evolved as gas; but there is no organic substance, ex-
acid, in which the quantity of nitrogen is too great to be
monia by the hydrogen thus liberated from the alkaline
vever, cyanide of potassium or sodium is formed in the
, if a sufficient excess of the alkaline hydrate is present,
when the heat becomes very strong, and the whole of the
nonia. It is on these facts that Will and Varrentrapp's
n is founded.

um and sodium are very deliquescent, and act strongly on
is convenient to mix them with quick lime, which makes
diminishes their action on the glass. The mixture
containing 1 pt. of hydrate of sodium, and 2 pts. of quick
ng the requisite quantity of quick lime to caustic soda-ley
ing to dryness in an iron pot, calcining the residue in a
bing it to fine powder in a warm mortar. It must be
vessels with good stoppers. If commercial soda is used
previously tested for nitric acid, as the presence of that
nalysis.

ed is mixed in a warm porcelain mortar, with a quantity
ll about two-thirds of a combustion-tube, from 16 to
ime must be previously heated over a lamp to expel any
t may have absorbed, and the mixture must be made by
rwise portions of it will adhere obstinately to the mortar
een introduced into the tube, the mortar is rinsed with
with pounded glass, to remove any small portions of ad-
tube is filled up with soda-lime to within an inch of the
l asbestos being placed at the end to prevent the light
rward by the vapours.

in a bulb-apparatus of the form shown in *fig.* 40, con-

Fig. 40.



ecific gravity about 1·10), sufficient to half fill one of the
s is adapted to the combustion-tube in the manner shown
radually heated from end to end. Ammonia is then given
ydrochloric acid. Towards the end of the combustion, the
reased, in order to decompose any cyanide of sodium that
er stage of the process. When the combustion is finished,
n off, and air drawn through the apparatus in the usual way.
le Paris, i. 105) recommends to place at the closed end of
ate of calcium and slaked lime (obtained by neutralising
e, boiling the precipitate with excess of lime, and drying
when decomposed at the end of the operation, evolves a
eps all the ammonia remaining in the combustion-tube into

ed into a capsule, and the bulbs are rinsed with alcohol,
distilled water. Sometimes oily hydrocarbons are formed
collect on the surface of the acid liquid. In this case it
ther, to separate the oil from the acid liquid by filtration,
oistened with water. Bichloride of platinum is now added
recipitates the ammonia as chloroplatinate of ammonium,
evaporated to dryness over the water-bath; and the dry
with a mixture of 2 volumes of strong alcohol and 1 vol

ether, which dissolves the excess of bichloride of platinum, and leaves the chloroplatinate of ammonium. This salt is collected on a weighed filter, washed with th same mixture of alcohol and ether, then dried at 100° and weighed; 100 pts. of correspond to 6·279 pts. of nitrogen. Or, the salt with its filter may be ignited in weighed crucible of platinum or porcelain, till the filter is completely burned to ashe and metallic platinum is left. The ignition must be performed with great care commencing with a very gentle heat, which should be increased very gradually because the vapours of sal-ammoniac and chlorine which escape are very apt to carry with them a small quantity of platinum: 100 pts. of platinum correspond to 14·20 pts. of nitrogen.

The process just described may be applied to most azotised organic bodies withou further modification. Sometimes, however, when the proportion of nitrogen is large as in urea, mellone, &c., the whole of the hydrogen is given off as ammonia. In thi case, the quantity of uncondensable gas evolved is comparatively small, and toward the end of the process, the acid in the bulbs is very likely to be suddenly drawn bac into the combustion-tube. This accident may be prevented by adding to the mixtur a small quantity of sugar or tartaric acid, so as to dilute the ammonia with uncondensable gases.

Liquids containing nitrogen may be treated in the same manner, being enclosed i bulbs, as for combustion with oxide of copper.

There are some azotised organic bodies to which Will and Varrentrapp's process i not applicable,—those, namely, in which the nitrogen exists in the form of an oxide generally as NO^2 (the so-called nitro-compounds): these bodies, when ignited wit an alkaline hydrate. giving off only a portion of their nitrogen in the form of ammonia so that the quantity found is always too small.

Other azotised bodies, when heated with soda-lime, give off, not ammonia, but organi bases free from oxygen, and more or less resembling ammonia. Thus indigo yield phenylamine (C^6H^7N), and many non-volatile organic bases, *e.g.* narcotine, morphine quinine, and cinchonine, give off organic volatile bases. Many non-oxygenise organic bases, such as phenylamine, chinoline, &c., pass over ignited soda-lime withou decomposition, or at all events do not yield all their nitrogen in the form of ammonia Now all these volatile organic bases form platinum-salts, in which, as in chloroplatinate of ammonium, 1 atom of platinum corresponds to 1 atom of nitrogen. If therefore, these bases are treated by Will and Varrentrapp's process, the resultin platinum-salts ignited, and the metallic platinum weighed, 100 pts. of it will correspon to 14·204 pts. of nitrogen, whatever organic base may have been formed in the decomposition. As, however, the platinum-salts of many of these bases are more soluble i alcohol than chloroplatinate of ammonium, it is best to wash them, not with the mixture of alcohol and ether above-mentioned, but with absolute ether to which only few drops of alcohol are added. In all cases in which it is not certainly known that the body submitted to analysis gives off the whole of its nitrogen as ammonia, the chloroplatinate should be ignited after being weighed, and the residual platinum weighe again, so as to ascertain whether the chloroplatinate weighed was really chloroplatinat of ammonium. (NH^4PtCl^3 corresponds to 44·3 per cent. platinum.)

Instead of precipitating the ammonia with bichloride of platinum, its quantity ma also be determined volumetrically, for instance, by receiving it in dilute sulphuric aci of known strength, and estimating the quantity of free acid remaining by means of standard alkaline solution. Péligot uses for this purpose dilute sulphuric acid, containin 61·25 grms. of SO^4H^2, in a litre of liquid; neutralises it with a measured quantity o a solution of lime in sugar-water; and compares the quantity of the lime-solution required for this purpose with that which is required to neutralise the same volume o acid after absorption of the ammonia. Instead of the solution of lime in sugar-water which quickly varies in strength, and must be standardised before each experiment, i is better to use a standard solution of caustic soda (see Acidimetry, and Analysis Volumetric). If an acid be used containing 1 at. SO^4H^2 in a litre of liquid, and solution of soda containing 2 at. NaHO in the same volume of liquid, the quantity o acid saturated by the ammonia will be very readily found, and thence also the quantit of ammonia absorbed. These methods, being more rapidly executed than the platinum determination, are especially applicable in the determination of nitrogen for technica purposes, in the valuation of guano for example.

Other modifications of Will and Varrentrapp's process have been proposed, fo example, receiving the ammonia in tartaric acid,—but they do not appear to present any peculiar advantages.

Estimation of Chlorine.

Organic bases combine with hydrochloric acid, forming salts (the hydrochlorate o morphine, for example), from the solutions of which chlorine may be completely preci-

itrate of silver. But many organic compounds contain
i cannot be precipitated as chloride of silver, until the
royed.
n adopted in such cases is to ignite the compound with a
rth, generally with quick lime. The lime used for the
cting marble to a strong red heat in a crucible. It must
that element is found in it, the lime must be slaked, and
rated from it by washing with water, after which it is to

solid, is mixed in a mortar with the pure pounded lime,
a combustion-tube from 12 to 18 inches long, and the
, or (in order to diminish the quantity of lime which has
in nitric acid) with a mixture of lime and pounded glass.
in the usual manner; afterwards, while the tube is still
y a cork, it is then wiped with a piece of filter-paper, and
tall glass cylinder about one-third full of cold distilled
on thus coming in contact with the water, and its contents
the excess of lime is dissolved by nitric acid. The liquid
, and the chlorine precipitated by nitrate of silver. Or,
n cold are turned out into a jar of distilled water, and the
cid. This method, however, is more subject to error than
to prevent a portion of the very fine dust of lime being
e emptying the tube into the water.
ne are enclosed in bulbs in the manner already described
ssed over the red-hot lime.
nic compounds are estimated in like manner.

ESTIMATION OF SULPHUR.

tained in organic compounds in such a manner that it
ith metallic solutions; more generally, however, its sepa-
y the complete destruction of the compound. In some
nitric acid will effect the decomposition, the sulphur being
id; but a more certain method is to fuse the compound
arbonate, mixed with nitre, chlorate of potassium, or oxide

few lumps of hydrate of potassium are fused in a silver
ith about $\frac{1}{8}$ of nitre, a few drops of water being added to
ed quantity of the sulphuretted organic compound is then
ortions, and the heat is gradually raised, small quantities
om time to time, if necessary, to burn away the carbon.
dissolved in boiling water, the excess of alkali neutralised
ide of barium then added, and the precipitate of sulphate
nd ignited with the usual precautions. (See SULPHURIC

lso, whether fixed or volatile, be burnt in a combustion-
nate of sodium, with nitre, chlorate of potassium (Kolbe),
ll, Chem. Soc. Qu. J. vii. 212),—non-volatile pulverisable
the carbonate of sodium and the oxidising agent, volatile
aled bulbs, and volatile solids and fatty bodies placed in

ESTIMATION OF PHOSPHORUS.

lies is estimated by burning the substance with a mixture
itre or chlorate of potassium, in the same manner as for
he resulting phosphoric acid as phosphate of magnesium
or *arsenic*.
nces occurring in organic compounds are estimated by the
o each of them, in the residue left after the organic matter

nating sulphur, phosphorus, chlorine, &c., in organic com-
y Carius (Ann. Ch. Pharm. cxvi. 1), consists in heating
acid, of specific gravity about 1·2, in a sealed tube.
y all cases, completely converted into sulphuric acid, and
ride of barium; *phosphorus* and *arsenic* are converted into
s, and may be precipitated as ammonio-magnesium salts;
partly separated in the free state, but may be completely

converted into hydrochloric acid by means of a dilute solution of sulphurous acid or sulphite of sodium, and then precipitated by nitrate of silver; *bromine* and *iodine* are completely separated in the free state, and may be estimated in like manner; lastly, *metals* are converted into oxides or nitrates, and may be estimated by the ordinary methods of mineral analysis.

This method of oxidation by nitric acid in sealed tubes, is likewise applicable to many inorganic compounds, the sulphides of arsenic, for example. (For details, see the articles CHLORINE, PHOSPHORUS, SULPHUR, &c.)

DETERMINATION OF THE CHEMICAL FORMULA OF AN ORGANIC COMPOUND.

When the quantities of the several elements of a compound which make up a given weight, say 100 parts, are known, it is easy to calculate the *relative* number of atoms of these elements. For, since the actual weight of a substance (W) is equal to the weight of each atom (A), multiplied by the number (n) of the atoms ($W = nA$), it follows that the number of atoms is equal to the total weight divided by the atomic weight ($n = \frac{W}{A}$); so that, when the percentage composition is known, the relative numbers of the atoms—in other words, the empirical formula—will be found by dividing the percentage of each element by its atomic weight, and reducing the result to its simplest numerical expression.

For example, sorbic acid is found by Hofmann's analysis (Chem. Soc. Qu. J. xii. 46) to contain in 100 parts: 64·38 C, 7·20 H, and 28·42 O. Therefore:

$$\text{Number of Carbon-atoms} = \frac{64{\cdot}38}{12} = 5{\cdot}36 \text{ or } 3$$

$$\text{,, Hydrogen-atoms} = \frac{7{\cdot}20}{1} = 7{\cdot}20 \text{ or } 4$$

$$\text{,, Oxygen-atoms} = \frac{28{\cdot}42}{16} = 1{\cdot}77 \text{ or } 1$$

consequently, the simplest atomic expression of the constitution of sorbic acid is C^3H^4O.

Whether this is the real expression for the composition of the molecule, or whether it should be $C^6H^8O^2$, or $C^9H^{12}O^3$, or any other multiple of the first formula, must be determined by other considerations. In the case of an acid, we naturally look to the constitution of its salts, the barium- and silver-salts being generally selected as being the most easily prepared and analysed. The analysis of sorbate of barium gives:

	In 100 pts.		at. wt.		No. of atoms.
Carbon . . .	40·37	÷	12	=	3·36 or 6·08
Hydrogen . . .	4·02	÷	1	=	4·02 or 7·27
Barium . . .	37·89	÷	68·5	=	0·55 or 1
Oxygen . . .	17·72	÷	16	=	1·11 or 2
	100·00				

This approaches very nearly to the formula $C^6H^7BaO^2$, showing that the rational formula of sorbic acid is, not C^3H^4O, but $C^6H^8O^2$, supposing the acid to be monobasic, or $C^{12}H^{16}O^4$, if it is dibasic. Which of these hypotheses is correct must be determined by other considerations (ACIDS, p. 46). The monobasic formula is adopted because it is found that sorbic acid forms but one class of salts, one ether, one amide, &c.

The rational formulæ of bases are also determined by the constitution of their salts. The platinum-salts are most generally relied on, because they can be easily obtained pure, and the platinum can in most cases be determined with great accuracy. The rational formula of the base is that which corresponds to 1 atom of platinum. Thus the platinum-salt of *nitranisidine* gives numbers corresponding to the formula, $C^7H^8N^2O^3.HCl,PtCl^2$: hence the formula of the base is $C^7H^8N^2O^3$. In some cases, the gold-salts are better adapted than the platinum-salts for determining the constitution of an organic base. But any well defined and stable salt in which the amount of acid or acid-radicle can be directly and accurately determined, will answer the purpose equally well.

To determine the rational formula of a compound which is neither acid nor basic, recourse must be had to its derivation and to its modes of decomposition. Thus indigo yields by analysis numbers corresponding to the formula, C^8H^5NO. By oxidising it with nitric acid, we obtain *isatin*, $C^8H^5NO^2$ (= indigo + O); and isatin treated with potash yields the potassium-salt of *isatic acid*, $C^8H^6KNO^3$. Now, as isatic acid exhibits the characters of a monobasic acid, this formula shows that it con-

onsequently isatin and indigo, which are related to it in
ust also contain 8 atoms carbon. Substitution-products
chlorine, nitric acid, &c. are often of great use in deter-
us the composition of mesitylol may be expressed em-
mulæ, C^3H^4, C^6H^8 or C^9H^{12}. But this body, under the
elds the three substitution-products, nitromesitylol,
$C^9H^{10}(NO^2)^2$, and trinitromesitylol, $C^9H^9(NO^2)^3$, the com-
rreconcilable with the formula, C^3H^4, or C^6H^8. Again,
night be expressed empirically by the formula, $C^{10}H^8$, or
e compounds, $C^{10}H^7Cl$, $C^{10}H^6Cl^2$, $C^{10}H^5Cl^3$, $C^{10}H^5BrCl^2$,
hows clearly that the higher formula is the true one.
ile without decomposition, its atomic weight may gene-
of its vapour-density. In nearly all cases, the mole-
seous state is supposed to occupy 2 volumes (Atomic
vapour-density is half the weight of the molecule, and
must be calculated accordingly. Thus the vapour-
ed by Gay-Lussac, is 1·6133, referred to air as unity, or

ydrogen as unity. The double of this number, or 46·5

molecule. Now the composition of alcohol, as deter-
is C^2H^6O, and the weight of the molecule calculated
formula of alcohol is therefore C^2H^6O and not any mul-

KIMATE ORGANIC ANALYSIS.

nate elements of which an organic body is composed, is
te idea of its constitution, unless the substance under
ical compound, such as sugar, alcohol, albumin, &c. In
at we wish to obtain, or indeed that we can obtain re-
body, is derived from its elementary analysis, together
reactions; but when a complex organ, as a leaf or a
luid, such as the sap, milk or blood, is to be examined, it
to the ultimate analysis, to separate the several definite
ts, of which the complex substance is made up; just as
nite, it is not sufficient to know the relative quantities
ium, oxygen, &c., which it contains, but we require
manner in which these elements are grouped in the
other words, to ascertain what proportions of quartz,
composition of the rock.
anic bodies is, as we have seen, reduced to a very com-
no element occurring in an organic compound which
nty, and estimated quantitatively within very narrow
ith the proximate analysis. With regard to vegetable
g more than a few general directions can be given. In
progress has been made towards the establishment of
ative analysis, but much remains to be done before the
rity and exactness to the processes of mineral analysis.
table or animal, solid or liquid, is divided into two parts,
the inorganic, the other for that of the organic consti-
and incinerated (see Ashes) and the ash examined by
ysis. The former, if the analysis is to be quantitative,
qualitative analysis, is dried at a temperature between
at care being taken not to let the heat rise too high, as
decomposed by heat. Some bodies must be dried at
er sulphuric acid. Liquids are first evaporated in
-bath, and the residue is then dried at a somewhat

riginal substance, is then subjected to the action of
ether, alcohol and water. Gerhardt recommends these
r here indicated: this of course implies that the sub-
Ether dissolves especially fatty and waxy substances,
ol dissolves the same substances with less facility,
solves many substances which are insoluble in ether;
mmy and amylaceous substances, and salts of organic
ntine, chloroform and sulphide of carbon, are also
alkalis are extracted by dilute sulphuric or hydro-

chloric acid; organic acids by dilute ammonia or potash. The solutions of vegeta acids, and of certain other substances thus obtained, are often treated with acetate subacetate of lead, in order to precipitate the organic principles in the form of soluble lead-salts, which are then decomposed by sulphuretted hydrogen. Acetate aluminium and ferric acetate are also used as precipitants.

The solutions obtained in this way generally contain a mixture of proximate orga principles, which must be separated by fractional distillation, precipitation, saturati or crystallisation: when crystals are obtained, it is mostly of great service to exam them by the microscope, in order to determine their form, and ascertain whether t are homogeneous.

Fractional precipitation with acetate of lead is much used for the separation of higher terms of the fatty acid series, stearic, palmitic, acid, &c. The mixture of fa acids is dissolved in alcohol; the solution is partially precipitated with acetate lead; the precipitate is decomposed by sulphuric acid; the fatty acids thereby se rated are redissolved in alcohol, and again partially precipitated; and this series operations is repeated till the fatty acid thus separated shows a constant melt point.

The method of *fractional saturation* applied by Liebig to the separation of some the lower terms of the fatty acid series, may also here be noticed. When valeric butyric acids occur together in a liquid, their separation may be effected by saturating the mixture with soda, and distilling. If the valeric acid is in excess, valerate of sodium is left behind, and a mixture of butyric and valeric acids dis over; if, on the contrary, the butyric acid is in excess, the residue contains butyrate well as valerate of sodium: but the distillate consists of pure butyric acid. On tilling the residue with excess of dilute sulphuric acid, the two acids pass over togeth and by partially neutralising the distillate with an alkali, and again distilling, a ther separation may be effected. At each stage of the process, the less volatile (the valeric) displaces the more volatile, and one only of the acids is found either the distillate or in the residue, according as the more or the less volatile acid pre minates. When a mixture of acetic acid with butyric or valeric acid is treated in manner, different phenomena present themselves, the acetic acid, though the m volatile, exhibiting the greater tendency to displace the other two and remain in residue. This peculiar behaviour is due to the formation of an acid acetate of sodi $C^2H^3NaO^2.C^2H^4O^2$, which is not decomposed by either of the other acids. Hen if the mixture contains more acetic acid than is sufficient to form an acid acetate w the quantity of soda added, the excess will pass over together with the whole of butyric or valeric acid present, the residue consisting of pure acid acetate of sodiu if, on the contrary, the quantity of acetic acid is less than sufficient to convert whole of the soda into the acid acetate, pure valeric or butyric acid will pass over, the residue will contain acid acetate of sodium, mixed with butyrate or valerate.

Volatile oils are separated by fractional distillation. The roots, seeds, leaves, & containing them are macerated in water and distilled, and the oils which pass o with the aqueous vapour, are separated mechanically from the watery distillate, subjected to fractional distillation, the portions which distil at constant boiling poi or between narrow limits of temperature being collected apart. Many volatile have the composition of aldehydes, and these are separated from mixtures contain them, by agitation with a saturated solution of acid sulphite of sodium, with which th form crystalline compounds.

In most cases, however, more information will be obtained concerning the b method of procedure in any particular case, by consulting the methods which actually in use for separating special substances from complex mixtures in which th occur, than from any general rules: see for example the articles ALKALOIDS (DETECT OF), BONE-OIL, CINCHONA-BARK, OPIUM, for the methods of separating alkaloids; articles BILE, OLEIC ACID, STEARIC ACID, URIC ACID, &c., for the methods of separat acids; and the articles ALBUMIN, GLYCERIN, SUGAR, &c., for the methods of separat neutral bodies.

Examination of Animal Substances: Zoochemical Analysis.—T general directions just given for the proximate analysis of complex organic bodies, for the most part equally applicable to vegetable and to animal substances: but proximate principles of the animal body being less numerous than those of vegetable kingdom, where distinct proximate principles occur in every natural or and in many individual species, it is somewhat easier to lay down a systematic cou for the qualitative analysis of animal substances. The following is the method gi by Gorup-Besanez, in the *Handwörterbuch der Chemie*, 2^{te} Aufl. i. 984.

a. For liquids.—The physical characters must first be examined. Any turbidity sediment occurring in the liquid is to be examined by the microscope for the detecti of crystals, or bodies of any other definite form. An acid reaction of the liquid i

ls or of acid salts; an alkaline reaction, that of free
phosphates (as in blood, blood-serum, and serous transu-
from decomposition (as in urine). A coagulum forming
n a liquid originally clear, generally consists of fibrin; it
bodies, a question to be decided by examination with the

ssary, by filtration or straining, is now to be examined

d in a test-tube to the boiling point, acetic acid being
t is attained, in sufficient quantity to produce a faint
d was originally neutral or alkaline.
formed, **albumin** is absent: pass on to (2).
rbidity is produced: Divide the liquid into two portions.
rops of dilute hydrochloric acid. If the precipitate dis-
nt earthy phosphates are probably present. Look for
chemical tests.
does not disappear, add hydrochloric acid and heat to
s gradually, with blood-red colour, **albumin** is present:
few drops of nitric acid to a small quantity of the

d by boiling the liquid, or the liquid itself, has a reddish-
in may be present. The coagulum is then to be digested
acid, and the liquid treated with the tests specially
se compounds.
coagulum is produced by boiling, or the liquid filtered
rary case, may still contain the following albuminoïdal
metalbumin, **casein** and **globulin**.
duced on boiling the liquid, **paralbumin** or **metal-**
acetic acid during ebullition; if the liquid then becomes
ields a turbid filtrate, if it also gives a precipitate with
nitric acid, and the last-mentioned precipitate is inso-
paralbumin is present. Then look for metalbumin
of potassium. If alcohol produces a precipitate soluble
but ferrocyanide of potassium produces no precipitate,

tly clear on boiling, it may still contain the following
derivatives; **casein**, **globulin**, **glutin**, **chondrin**,

mixed with ferrocyanide of potassium. If it remains
absent: pass on to (3).
st for **casein** with solution of chloride of calcium and
for **globulin**, by observing whether a precipitate is
tion after it has been made acid or alkaline.
add acetic acid. If it remains clear, **pyin**, **mucus**,
ss on to (4).
the solution with corrosive sublimate. If no precipi-
The occurrence of a precipitate indicates the presence
by tincture of galls and neutral acetate of lead. If the
erely a turbidity, chondrin is perhaps present. Con-
d: the formation of a jelly indicates **chondrin**, the
rmed by its behaviour to alum and metallic salts.
acid produced no precipitate may yet contain glutin.
and leave it to cool: the formation of a jelly will then
e further tested with corrosive sublimate.
f it contained albumin, the liquid freed from that com-
ted by a gentle heat to $\frac{1}{2}$ or $\frac{1}{3}$ of its volume, then heated

iquid is probably free from **urates**: pass on to (6).
acetic acid. If the hitherto amorphous masses are then
ssume the form of rhombic tablets, **uric** acid is present
nitric acid and ammonia.
altered by acetic acid points to the presence of **sul-**
phate of magnesium, which may be further sub-
nical examination. The precipitate, if crystalline, may
osin, **hippurate of calcium**, and **benzoic acid**.
the general behaviour of the substance must then de-
applied

6. The concentrated liquid in which no precipitate is formed by boiling and sul sequent cooling, or the liquid filtered from such a precipitate, is evaporated to a syru on the water-bath, and left to itself for a considerable time.

If crystals gradually form, it is left to stand as long as they continue to increas They may consist of creatine, creatinine, glyccocoll, leucine, allantoi taurine, sarcosine, inosite, alkaline hippurates, chloride of sodiu and other inorganic salts.

It must in the first place be determined whether these crystals are organic inorganic. In the former case, they must be tested especially for nitrogen, sulph and phosphorus (p. 221), their chemical character determined as nearly as possibl and the further examination regulated accordingly. In the latter case, they must treated by the methods of inorganic analysis. If they blacken when strongly heate but also leave a fixed residue, they probably consist of an organic acid combine with an inorganic base: in that case, the fixed residue will effervesce strongly wi acids.

7. The syrupy residue itself, or the liquid separated from the crystals which ha formed in it is evaporated nearly to dryness, and the residue exhausted with alcoh of specific gravity 0·833.

a. A portion of the alcoholic solution concentrated and then diluted with water, tested with nitric acid containing nitrous acid, for bile-pigment:—*b.* A second portio treated in like manner, is tested with sugar and sulphuric acid for the acids of bile:- *c.* A third portion is evaporated nearly to dryness, the residue dissolved in water, an the solution examined by Trommer's or Fehling's test for sugar:—*d.* A larger portio of the alcoholic solution is evaporated to a small bulk, the cooled residue treated wi nitric acid free from nitrous acid, and the vessel immersed in ice-cold water or in freezing mixture. A laminar crystalline precipitate exhibiting the micro-crystalli characters of nitrate of urea, indicates urea (care must be taken to distinguish from nitrates of the alkalis). A crystalline precipitate appearing after some time, more quickly after previous heating, indicates hippuric or benzoic acid, the pr sence of which must be verified by the microscope and by chemical reactions:—*e.* Mix portion of the concentrated alcoholic extract with a syrupy solution of chloride of zin if a crystalline precipitate forms, it may contain creatine and creatinine: if such precipitate appears after a considerable time, creatine is certainly absent:- *f.* The last portion of the concentrated alcoholic extract, which will exhibit a stro acid reaction, if any free acid is present, is to be heated with oxide of zinc, filter hot, and a drop left to evaporate on a glass plate: if lactic acid is present, the ch racteristic club and tun-shaped crystals of lactate of zinc will be seen by examinati with the microscope. The presence of lactic acid may be confirmed by preparing pure salt of the acid from a larger quantity of the liquid.

8. The residue insoluble in alcohol may contain, in addition to inorganic and s called extractive matters, uric acid, guanine, hypoxanthine, and albun nates not precipitated by boiling. It must be exhausted with water, which takes casein, pyin, and extractive matters, together with soluble salts, then with dilu potash solution, which dissolves uric acid, hypoxanthine, and guanine, and lastly, wi dilute hydrochloric acid. What then remains may contain albuminates which ha become insoluble, mucus, and perhaps also silica. All these substances must further looked for by special tests.

9. Part of the original liquid is evaporated to dryness, and the residue, pulveris if possible, is exhausted with ether. The ethereal extract, chiefly containing fats solution, is evaporated and further examined (see Fats and Glycerides). The resid insoluble in ether is incinerated, and the ash examined by the methods of inorgan analysis.

β. Tissues and Organs.—In the analysis of animal tissues, it is absolutely necessa to operate with considerable quantities of material, not less than 20 pounds; otherwi a very tedious investigation may be gone through without any satisfactory result.

The tissue is first carefully comminuted and completely exhausted with cold wate the extract is freed from albumin by boiling, and to the filtered liquid a concentrat solution of caustic baryta is added as long as any precipitate or turbidity is produce The precipitate may contain phosphate of barium, phosphate of magnesiu sulphate of barium, uric acid, and hypoxanthine. The filtrate is evaporat to a syrup over the water-bath, care being taken to remove any mucous films li casein that form during the evaporation. These generally consist of carbonate barium or phosphate of magnesium, but may also contain uric acid, hypoxanthi or barium-salts of organic acids; they must, therefore, not be thrown away. soon as the filtrate is concentrated to the consistence of a thin syrup, it must be le to evaporate spontaneously. If small short colourless prisms form in it, th

; as soon as they appear to be completely deposited.
n the mother-liquor, recrystallised, and submitted to

further evaporated, and mixed with small portions of
is produced, after which the mixture is left to itself for
ar, or needle-shaped crystals form in it, they may con-
osphate of magnesium. inosate of potassium and
tain the inosic acid, dissolve the deposit in hot water,
he inosate of barium which separates by crystallisation,
y precipitation with dilute sulphuric acid.
he deposit of inosates is now to be mixed with a fresh
it generally separates into two layers, the lower being
. The upper layer is decanted, and the lower is mixed
, which generally causes a fresh separation. The lower
ntain alkaline lactates, inosite, and salts of the
pper, creatinine and leucine. The ether-alcoholic
to crystallise. If the residue gradually deposits fine
ith a little alcohol, filter off the mother-liquor, and treat
hol; they may contain creatine and creatinine. The
y as the filtrate cools; the creatinine crystallises from

xed with the mother-liquor of the creatine and creatinine
lphuric acid, in order to precipitate all the baryta, and
n the volatile acids. The residue of the distillation, if
haps yield lactic and succinic acids.
ion, after being freed from these acids, is mixed with
turbid, and left at rest. Sulphate of potassium then
edly adding fresh portions of alcohol, more sulphate of
site, which must be separated from the sulphate of
y mechanical means, and then by recrystallisation from
ter. To obtain hypoxanthine and uric acid from the
hich separated in films at the beginning of the process,
by adding sulphuric acid to separate the volatile acids
ith boiling potash-ley, filter, acidulate with hydrochloric
precipitate in potash, and add sal-ammoniac. Uric
rate of ammonium, while hypoxanthine remains in
by evaporation as a yellowish-white powder.
gulum of albumin, after being evaporated to a syrup,
ped crystals, but after standing for some time, masses
t and unctuous to the touch, and appearing under the
cting spherules, the presence of leucine may be sus-
n to be separated from the mother-liquor, which, after
posits more of them, and the entire product strongly
and purified by repeated crystallisation from boiling
nt, it covers the filtrate, after it has been freed from the
ated, with numerous stellate groups of slender needles,
n undissolved when treated with alcohol. They may be
ence they separate on cooling,—purified by solution in
n of acetate of potassium, and boiling,—and then further

e leucine and tyrosine deposits are examined as above
id, succinic acid, inosite, &c.

amination of animal tissues is given by Städeler and

aceration and pressing are boiled with a few drops of
min and colouring matter of blood, and the strained
over the water-bath to $\frac{1}{10}$ of its bulk, is precipitated
precipitate, which may contain uric acid and inosite,
shed; the filtrate is freed from excess of lead by sul-
orated to a syrup; the residue, which generally contains
m these compounds by digestion in cold weak alcohol;
cohol is then added as long as a precipitate of alkaline
and the excess of sulphuric acid is removed by careful
he clear filtrate evaporated till it no longer becomes
xed with an equal volume of absolute alcohol, is heated
nd then left at rest. Any crystals which separate must

be further examined: they may consist of creatine, but also of tyrosine a taurine, which last compound has lately been found by Cloëtta in the tissue of lungs. The mother-liquor of the crystals, if carefully evaporated to a smaller bu deposits any leucine that may be present.

The precipitate produced by subacetate of lead is washed, suspended in water, a decomposed by sulphuretted hydrogen. If the liquid filtered from the sulphide of l deposits, after some time, small white crystalline grains, exhibiting under the mic scope the forms of uric acid, they must be collected and examined for uric acid the murexide test (URIC ACID). The liquid filtered from the uric acid is evapora over the water-bath, till a sample mixed with alcohol becomes permanently turl The entire liquid is then mixed with an equal volume of alcohol, and warmed till turbidity disappears. If after some days, a deposit forms on the bottom and sides the vessel, consisting of crystalline masses, which, when recrystallised from water, fo rhombic prisms insoluble in alcohol and ether, having a pure sweetish taste, and le ing no residue when burnt, inosite is probably present, and must be sought for other tests. [For further details, and for the quantitative analysis of animal substan see Lehmann, Lehrb. d. physiolog. Chem. 2te Aufl. Leipzig, 1853; Heintz, Leh d. Zoochemie, Berlin, 1853; Robin et Verdeil, Traité de Chimie anat. et phys Paris, 1858; Gorup-Besanez, Anleitung zur zoochem. Analyse, 2te Aufl. Nürnbe 1854.]

ANALYSIS (VOLUMETRIC) of LIQUIDS and SOLIDS. The meth usually employed by chemists to determine quantitatively the constituents of a m ture, consists in separating them out one after the other, either in the pure state, or the form of some compound of known composition, and weighing the products. Ev one who has occupied himself with such separations knows how much time they usu require; indeed the value of an analytical result is very often much less than that the time and trouble spent upon its determination. We are indebted to the sagac of Gay-Lussac for the introduction of a new principle in analytical chemistry, which many instances obviates the inconvenience mentioned. This consists in submitting substance to be estimated to certain characteristic reactions, employing for s reactions liquids of known strength, and, from the quantity of the liquid employ determining the weight of the substance to be estimated by means of the known law equivalence. Let us, for example, consider the problem which suggested to G Lussac the idea of this method. Suppose it be required to determine the amount silver in an alloy of silver and copper. The older analytical method consists in d solving a weighed quantity of the alloy in nitric acid, precipitating the silver chloride by the addition of hydrochloric acid, then filtering, washing, fusing, a weighing the resulting chloride of silver. From the known fact that chloride of sil contains $\frac{108}{143.5}$ of its weight of silver, the amount of silver in the alloy is calculat The same result is evidently obtained by preparing a solution of chloride of sodium known strength, and ascertaining how much of the solution is necessary and suffici to precipitate the silver as chloride of silver from a solution of a weighed quantity the alloy in nitric acid. The weight of the precipitated silver may be determin from the amount of the chloride of sodium employed; because it is known that 5 parts by weight of chloride of sodium are exactly sufficient to convert 108 parts silver into chloride of silver.

The liquid reagents of known strength employed in determinations of this nature called "standard solutions." The amount of standard solution employed in a det mination may be estimated either by weight or by volume; but inasmuch as t latter method has been found easier of application, it is now universally employ and hence the method of analysis based upon the use of standard solutions is cal "volumetric analysis." At first glance it would seem that nearly all analyti methods based upon weight might be transformed into processes by volume, as in the c of the silver determination above quoted. This is, however, not always possible. A re tion to be applicable in volumetric analysis must satisfy two conditions. (1.) It must r occupy much time; precipitations, for instance, which take place gradually are at o to be rejected. (2.) The termination of the reaction must be recognisable with ease a certainty. Hence the number of possible volumetric processes is much limited. the other hand numerous reactions inapplicable in weight-analysis furnish excell means for volumetric determinations.

It is proposed in this article to give a short introduction to volumetric analy and for this purpose the subject will be divided into three parts:

I. Description of the necessary apparatus.
II. General rules for the preparation of standard solutions.
III. Description of the most important volumetric methods as yet discovered.

use, and verification.—Besides the apparatus necessary
ons, such as beakers, basins, &c., the performance of
(1.) a delicate balance and weights. (2.) Graduated
nt and preparation of the standard solutions. A balance
n of the standard solutions, and for weighing the sub-
od analytical balance capable of weighing 100 grammes
poses. To those who have many volumetric analyses to
balance with short arms is of great use. Such balances
ng than can be obtained by the ordinary laboratory

the units of weight and measure adopted, may of course
e French decimal system of weights and measures offers
on account of the simple relation which it establishes
and weight, that its employment in the sequel in all data
no justification.

re the standard solutions accurately, certain precautions
will now proceed to consider more particularly.
s poured out of a vessel, the vessel is, as is well known,
small portion of the solution remains always upon the
el has been long held in an inclined position. In using
st, therefore, be careful to note whether the *dry* vessel,
e, holds the required volume, or whether such volume is
en it is emptied in a certain manner. In the first case
ated for the contents; in the second for delivery
off is performed by bringing the eye and the surface of
line, and noting what division of the volumetric instru-
id surface. Now aqueous liquids which are enclosed in
ys show a concave surface, which is the more strongly
sel. But a curved surface is of course opposite to *many*
n order to avoid the ambiguities which are here intro-
ading off must be invariably adopted. The following
e best. A small piece of black paper is fastened a few
of the liquid by means of a caoutchouc ring; the instru-
ctly vertical position, one eye is closed, and the other
on. The meniscus then appears by transmitted light,
black line, by means of which it is easy to see with
former coincides (see ANALYSIS OF GASES). In order to
t the eye, the meniscus, and a distant horizontal line, of
e eye, are either brought into one horizontal line, or the
t distance before a vertical strip of mirror, and the eye
n that the image of the pupil and that of the meniscus
sible: the scale is then read off.
the volume of every body varies with the temperature,
ivisions on a measure for liquids, as well as the strength
plicable for one temperature only. The expansion of the
y be always neglected in volumetric analyses. A glass
lds a liter at 15° C. contains at 15° + 10°, one litre +
e only the $\frac{1}{4000}$ of a litre. The expansion of liquids is
to account in exact experiments.
nded to when volumetric instruments are to be graduated
ater which they hold. In this case the correction for the
s not the only one to be made. Since one gramme is by
of one cubic centimetre of water at + 4° C., the volume of
.c. is never expressed by the same number as its *apparent*
+ 4° C. There is of course no necessity for employing
volumetric analyses; but, as everything connected with
be as precise as possible, we think it advisable to use
etre, &c., in their strict sense.* We therefore give the
which the apparent weight of a certain required volume

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researches, cases in which *absolutely* correct measures must be em-
r of 0° C. has the weight of 1·293 grms., only when its tension is
cury column 0·76 *real* metres high, the litre being the volume of a
lances *in vacuo* the kilogramme employed.

The weight of 1000 c.c. of water of t° C. when determined by means of
weights in air of t° C. and of a tension of 0·76 metres, is equal to 1000 − x grms

t°	0	1	2	3	4	5	6	7	8	9	10	11	12	13	1
x	1·25	1·20	1·18	1·13	1·12	1·12	1·14	1·16	1·21	1·27	1·34	1·43	1.52	1·63	1·7

t°	16	17	18	19	20	21	22	23	24	25	26	27	28	29	3
x	2·04	2·20	2·37	2·55	2·74	2·95	3·17	3·39	3·63	3·88	4·13	4·39	4·67	4·94	5·

When the barometer stands at 76 ± n centim., every x is to be replaced by
0·014 n. The variations of atmospheric pressure may however be neglected, un
a very great degree of exactness is required.

If the strength of a standard resolution is known for one temperature, the stre
corresponding to another temperature can only be calculated, if the rate of expan
by heat of the liquid is known. It would lead to entirely wrong results if such
culations were founded on the known expansion of pure water, as experiment
shown that even weak solutions of salts and acids expand far more than w
(see **Gerlach** "Specifische Gewichte der Salzlösungen, &c.," Freiberg). As
as the expansion of the commonly used standard solutions is not directly de
mined, it is advisable to estimate the strength of such solutions not only by volu
but also by weight, which is easily done by weighing a known volume of the li
immediately after its strength has been determined. The ratios of the *weight* of
solution to the weight of active substances in it, is of course independent
temperature.

It is a matter of course that such corrections are appropriate only where the er
from other sources are not greater than the corrections themselves.

We may now proceed to describe the separate instruments.

1. *Pipettes.*—Glass vessels of forms shown in *figs.* 40* and 41, provided with a si
mark upon the narrow neck, and which are only graduated for delivery. In u
them, they are filled, at a little above the mark, by suction, and then closed above
the forefinger of the right hand. The lower point is brought in contact with a
piece of glass; the liquid is allowed to flow out, by very gentle displacement of
finger, as far as the mark; and the finger is then removed, to allow it to run out
the vessel employed. The drop of liquid in the point of the pipette is to be kep
exactly the same conditions as during the marking of the pipette; *i. e.* it is ei
totally neglected, or it is partly removed by holding the point against the wet sid
the glass, or it is to be blown out entirely. If the same method of evacuation
always faithfully followed, we may assume that, with all thin liquids, equal volu
remain adhering to the sides of the vessel.

It is convenient to be provided with such pipettes containing 100 c.c., 50 c.c., 20
10 c.c., and 5 c.c. Pipettes of 10 and 5 c.c. may conveniently have the form of *fig.*
larger ones the form of *fig.* 40*. It seldom happens that we have to make pipettes
selves, as they may be bought at a low price; but they should always be veri
This is easily done by filling them with water of a known temperature, pouring
into a tared flask, and weighing. The volume of the water may then be found f
its weight by means of the table above given.

2. *Pipettes* which are divided throughout their whole length and graduated
delivery. It is sufficient to have one of 50 c.c., which is divided in half c.c. (*fig.*
and several of 2 to 3 c.c., divided into $\frac{1}{10}$ c.c. (*fig.* 43).

3. *Flasks*, graduated for the contents (*fig.* 44), in various sizes, from $\frac{1}{10}$ litre
5 litres. They may be easily made by making an arbitrary mark upon the neck
the flask, and then measuring the volume by pipettes. It is more exact to we
the contained water. It is convenient if, but not absolutely necessary that, the volum
of these flasks should be whole numbers, such flasks being used only for the prepa
tion of standard solutions.

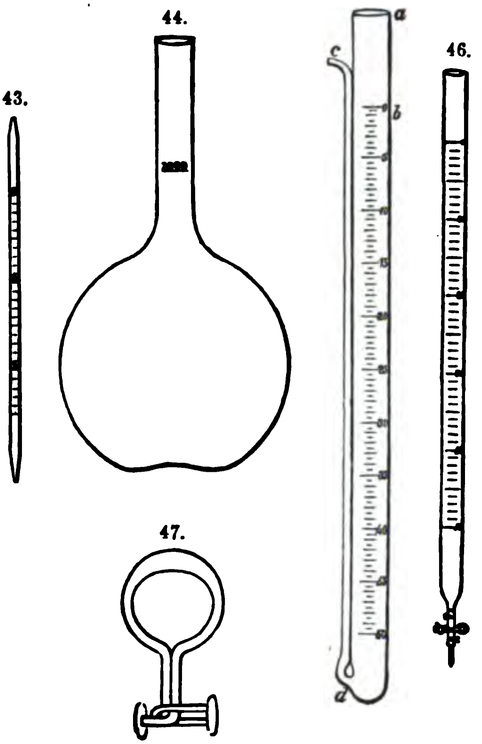
4. For measuring the liquids used in an analysis the *burette* is most gener
employed. This is an ingenious instrument invented by Gay-Lussac. Upon a g
tube (*fig.* 45) about 16 – 18 mm. wide and 30 centim. long, a narrow tube is fused a
carried up *close* along the wide tube to about 2 ctm. from its upper end, and th
(at *c*) bent and cut off in the manner shown by the figure. The divisions of $\frac{1}{2}$
begin about one ctm. below *c*, and the instrument is graduated "for delivery." In us
the burette it is washed out with some of the standard solution, then filled to 0 :
point *c* is slightly greased, and the required quantity of liquid is poured out of
narrow tube.

After some practice it is easy to allow the liquid to flow out either in a stre

t not be read off before the surface has attained a constant
ntimetres may, after some practice, be easily judged of by
to half cubic centimetres. It is erroneous to suppose that
y employing narrower tubes. The gain in accuracy due
f the divisions is lost, because in narrower tubes, the
ned, and the quantity of liquid adhering to the sides is
the dimensions given, contains 50 to 60 c.c., an amount
t analyses: larger burettes are inconvenient. If more
red in analysis, the greatest portion is measured off in a
nder added from the burette. In cases where greater
be attained by the burette, the latter is replaced by the

Gay-Lussac's burette a simple divided tube (*fig* 46), pro-

Figs. 40*—47.



43. 44. 45. 46. 47.

ouc tube, which is closed by a spring clamp (*fig.* 47)
s wire. Where a great number of analyses of the same
Mohr's burette is much to be preferred to Gay-Lussac's.
ever, where a greater diversity of analyses occur, the old
as caoutchouc is acted upon by some solutions which

te is performed either by the balance or by the pipettes

ndard Solutions.—Standard solutions may be divided into
prepared by weighing a substance of known composition
a certain volume; (2) such as are prepared by approxi
t exact analysis. The preparation of the first kind re-

quires no description. The preparation of the second may be effected by a kind successive approximation, which is best described by an example.

Let it be required to prepare a standard solution of sulphuric acid containin grammes of hydrate of sulphuric acid SO^4H^2 in 1 litre. The table given by Bineau the relation between the specific gravity and strength of sulphuric acid affords the b means for determining the strength to the first approximation. Pure sulphuric a (monohydrate, SO^4H^2) is diluted with about its own weight of water; the mixture allowed to cool, and its specific gravity is quickly and accurately determined by meas ing 100 c.c. in a pipette, weighing this, and dividing the weight (in grammes) by 100. the temperature be observed, the percentage of monohydrated sulphuric acid (p) m be determined by the table, to within a hundredth of its true value. Accordi to the result of this determination every $\frac{t}{p}\,100 = q$ grms. of the solution are luted with water up to 1 litre. From Bineau's table (see SULPHURIC ACID) t specific gravity (S) of the required solution may be seen. To every q grms. of ac $1000\,S - q = w$ grammes of water have to be added. An analysis performed w this mixture generally shows that it contains not t but t^1 grms. in 1 litre. Two ca are now possible:

(1) t^1 is greater than t. It is clear that the quantity t^1 of sulphuric acid contain in 1 litre is sufficient for $\frac{t^1}{t} = (1 + \Delta)$ litre. With every 1 litre of the mixtu Δ litre of water must be mixed, in order to bring it to the right strength. (2) t^1 less than t. From t^1 grms. of sulphuric acid only $\frac{t^1}{t} = (1 - \Delta)$ litre of standard so tion can be formed. Hence 1 litre of our mixture may be regarded as a mixture $(1 - \Delta)$ litre of right standard solution and Δ litre of water. Hence to every litre of t solution as much of the acid of p per cent. must be added as is sufficient to form t right standard solution, with Δ of litre water; and since by mixing q grms. of the per cent. acid with w grms. of water, we had obtained a mixture of nearly the rig strength, it follows that the quantity of strong acid which must be added to every lit is $\left(\frac{1000\,.\,\Delta}{w}\,q\right)$ grammes, neglecting an error which need not be considered, if Δ is small fraction.

After performing these operations, we must determine by experiment how nea we have arrived at the required strength, and, if necessary, make a second c rection. If the corrections required are great, it will be almost invariably foun on performing the analysis, that the strength required has not been exactly attain however carefully the mixture of the liquids may have been made. This is the ca even if the above described approximate synthesis is replaced by a theoretically ex one, this cause of the inaccuracy being, that in the measurement and mixture of la quantities of liquids, small errors of measurement and losses are difficult to avoid, a that the contraction of the mixture has been neglected. If, on the other hand, t solution to be corrrected is already so nearly right, that its strength differs by on 1 or 2 *per cent.* from that which is required, the result will be satisfactory, even if t volume of the liquid taken was only approximately determined, provided the analy was performed accurately, and the measurement of the small quantities of water acid which were added, were made with sufficient care.

If, for instance, we consider the case (1) and assume that the volume of the acid be corrected was found to be n litres, while in fact it was $n\,(1 + a)$ litres, the qua tity of water to be added would then be, not $n\,\Delta$ litres but $n\,\Delta\,(1 + a)$. The resulti volume of the mixture would accordingly be too small by $n\,\Delta\,(1 + a) - n\,\Delta = n\,\Delta\,a$. for instance, it is found that $a = \frac{1}{50}$, which seldom occurs, if moderate care is employe and $\Delta = \frac{1}{100}$, then the volume of the mixture would be $n\,\frac{2}{1000}$ litres too small, a consequently the amount of sulphuric acid in 1 litre would be too large by about $_{50}$ of its actual quantity. Similar considerations are applicable to case (2), and lead the conclusion that in the preparation of large quantities of liquids, according to t method just described, large measures accurately divided are not necessary. Such pr cesses are conveniently performed in large cylindrical bottles, which are divided do the side with divisions corresponding to entire decilitres. As the liquid in such ca is not transferred from one vessel to the other till it is quite prepared, loss is eas avoided.

The strength of a solution is best noted by giving the number (n) of gramm atoms of the active substance which it contains in 1 litre. By "gramme-ato we understand a number of grammes equal to the atomic weight of the substa (H = 1), for instance, 108 grammes silver, 28 iron, 35·5 chlorine, &c. It is clear th the calculations are hereby simplified. For instance, 1 litre of solution of silver, co

grms.) of silver exactly precipitates $n \times 35{\cdot}5$ grms. of
omine, $n \times 127$ grms. of iodine. It is also evident that
by making n a small number. If it can be done without
visable so to adjust the strength of the standard solution

nce that the standard solutions should remain of constant
dition, they must be carefully protected from evaporation
Large quantities may be preserved in bottles of 1 or 2
well ground stoppers. Bottles which are not in daily
stoppers greased and bound over with bladder or sheet

ost important Volumetric processes hitherto employed.—
methods hitherto discovered, those only are of general
which the analysis of a whole series of bodies can be made
tandard solutions. These alone will be more particularly
any methods applicable in special cases, reference must be
of this work.
may be classified as follows, according to the principles

on.—The quantity of the substance to be determined, is
gent required to separate it out in an insoluble state.
—The quantity of a base or an acid is measured by the
h is necessary to convert it into a neutral salt.
nd Reduction.—The quantity of substance to be deter-
ity of chlorine, bromine, iodine, or oxygen to which it is
lant), or by the quantity of chlorine, bromine, iodine, or
pass from a lower to a higher stage of oxidation.

ATION.—Of the numerous methods belonging to this divi-
hose only which depend upon the insolubility of the com-
alogens (chlorine, bromine, iodine, cyanogen).
acid solution of a chloride, bromide, iodide, or cyanide,
itrate of silver, it is well known that an insoluble chloride
precipitated, while a nitrate remains in solution. For

$$^3Ag + ClNa = ClAg + NO^3Na.$$

have the common property of forming, on violent agita-
pidly subsides. Hence it is possible to recognise exactly
cipitation is completed. The reactions mentioned may,
the one hand, to determine chlorine, bromine, &c., by
olution, and on the other, to determine silver by standard
des, &c.

etermination of Hydrochloric Acid and Chlorides.

in the form of foil or wire.
rate) containing $\frac{1}{10}$ gramme-atom (10·8 grm.) silver in
d by dissolving 10·8 grm. of silver in excess of nitric acid

atom = 1·08 grm. silver in 1 litre.
of sodium of $\frac{1}{10}$ grm.-atom (= 5·85) in 1 litre.
fused chloride of sodium is dissolved in water and diluted

of sodium saturated at ordinary temperatures, has a com-
of the temperature: it contains in 1 litre, 318·4 grm. of
$\frac{\times\ 5{\cdot}85}{18{\cdot}4}\Big)$ diluted to 1 litre, gives accordingly the standard

olution must, if properly prepared, be exactly equivalent to
must never neglect to try whether this is really the case
ed below, and if necessary to make the proper corrections.
of sodium containing $\frac{1}{100}$ grm.-atom in 1 litre = 0·585 grm.
ide of silver: this is obtained by mixing equal volumes of
usly and pouring off the clear liquid.
sis.—Let us at first assume that we have an approximate
f chlorine in the substance to be examined. In this case
duced into a bottle of clear glass with a well-fitting stopper,

dissolved in water or nitric acid, and the previously calculated quantity of stro
solution of silver (2) is added from a pipette. The quantity of substance, and t
of the water employed in its solution or dilution, are to be so taken that 100 c.c.
the mixture may contain 0·4 grm. to 1 grm. silver, and less than about 3 gms. of
dissolved salt. If a mixture has to be examined which is poor in chlorine, this re
tion is no longer possible. In such cases, enough freshly precipitated chloride of sil
(6) must be added to bring the quantity of silver present up to that mentioned. Sm
quantities of silver-precipitates disseminated through much liquid do not evince t
adherence and consequent tendency to subsidence which is necessary for the accur
performance of this mode of analysis. Solutions which are poor in chlorine, such
mineral waters, must be concentrated by evaporation previous to analysis. It is a
advisable in such cases not to employ a standard solution of silver, but to wei
metallic silver and dissolve it in a minimum of nitric acid.

The mixture obtained as above is now to be violently and continuously shaken,
it has lost its first milky appearance, and forms a mixture of curdy chloride of sil
in the midst of a clear solution. A speedy clarification is evidence of an excess
silver; slow subsidence indicates the reverse.

As soon as the chloride of silver has sufficiently subsided, ½ c.c. of strong solut
of silver must be added, in order to determine whether chlorine is still present in
solution. If no precipitation occurs, the ½ c.c. silver solution is neutralised by
addition of ½ c.c. solution of chloride of sodium; the liquid is then shaken, and ½
of solution of chloride of sodium being added shows whether silver is in solution.
us assume, for example, that the addition of the chloride of sodium has shown
presence of silver in considerable quantity. The amount of solution of chloride
sodium, which is exactly equivalent to this, cannot of course be known; but in eve
case we are sure of the existence of some maximum value (V c.c.) which certai
includes it. $\frac{V}{2}$ c.c. of chloride of sodium solution is then added, the mixture is shak
and ½ c.c. of the same solution being added shows whether the precipitation with
first quantity was complete or not. In the first case, $\frac{V}{4}$ c.c. of silver are added;
the second $\frac{V}{4}$ c.c. of chloride. In both cases, the completion of the precipitation
tested by the addition of ½ c.c. of test solution. By continually adding half
possible maximum of the necessary reagents, we soon arrive at a point when less th
½ c.c. of one of the two solutions is present in excess. When this point is arrived
cubic centimetres are added singly of the weaker ($\frac{1}{100}$ atomic) solutions, until the l
cubic centimetre leaves the liquid quite clear, This last c.c. is not at all consider
and the one preceding it is considered only of the value of ½ c.c. In this way, a res
is obtained, the error of which corresponds to less than ½ c.c. of the weak standard so
tion. It is easily seen that a systematic procedure like that given is quite essential,
order to arrive quickly at a result; by planless addition of standard solutions, we m
lose much time without arriving at any result. As long as $\frac{1}{10}$ atomic solutions are add
it is scarcely necessary to wait for a complete subsidence of the precipitate previou
formed. The white cloudy freshly precipitated chloride of silver is easily dist
guished from the previously precipitated, violet-coloured, and coagulated chlori
As soon, however, as we begin to work with $\frac{1}{100}$ atomic solutions, we must always w
for the complete clarification of the liquid before adding a fresh quantity of soluti
Weak precipitations are best seen by holding the vessel against the light, with a pi
of black paper obliquely behind it. The precipitation can be considered complete o
when the last cubic centimetre of solution gives no more turbidity after ½ to 1 minut
standing.

Those who make such analyses for the first time, will do well to place in seve
flasks some chloride of silver (6) and 100 c.c. water, then add to the several fla
¼, ½, 1, 2 milligrammes of silver; shake, and after subsidence add to each flask 1
of the $\frac{1}{100}$ atomic solution of chloride of sodium. By this means the judgment
greatly assisted in the subsequent actual reactions.

Experience has shown that it is not expedient to work with less than ½ grm. of sil
at once, and that no greater accuracy is obtained by adding less at once than 1 c.c
the $\frac{1}{100}$ atomic solution; the termination of the reaction is thereby only rendered m
indistinct.

If it be desired to arrive at the utmost accuracy in such determinations, a sec
analysis may be made by dissolving 1 grm. or more of silver in nitric acid, adding
quantity of substance necessary for its precipitation, as found from the previ
analysis, and completing the precipitation by means of the $\frac{1}{100}$ atomic solution.
determination of atomic weights, performed in this way by Marignac and Pelou
shows to what great accuracy the process may be brought.

It has been hitherto assumed that the amount of chlorine in the substance is

s not the case, the definite determination must be preceded
ity of the substance. The more exact such trial is made,
mance of the final determination.
alysis is very simple. The number of atoms of silver,
atoms of chloride of sodium, added as standard solution,
orine-atoms contained in the substance.
d for chlorine is applicable, *mutatis mutandis*, to bromine,

by means of chlorine also follows immediately from the
r explanation.*

on.—All methods belonging to this division depend upon
mmonia, baryta, strontia, and lime combine easily and
t the corresponding carbonates are fully decomposed in
with evolution of carbonic acid. The solutions of the
e named bases form with strong acids are without action
est excess of acid or alkali is immediately detected by its
getable colour.
ous *monocarbonate of sodium*. If this salt be kept ready
lways be ignited before use. Carbonate of sodium, fused
cast in slabs, is less hygroscopic, but its use must be
shown that carbonate of sodium loses on fusing a con-
acid.
ydrochloric acid, containing nearly or exactly 36·5 grms.
is may be prepared in several ways.
is to determine the specific gravity of a sample of con-
acid, deduce its strength by means of Ure's table † (see
Chlorine), add the proper amount of water and determine
nixture by means of silver solution, as described in a pre-

hose strength is approximately known from its specific
t it contains, as nearly as can be effected by this means,
e liquid so obtained be quickly boiled in a narrow necked
act with platinum (not in an open basin), a time soon
ric acid and water evaporate in the same proportion in
the residue. If about one half be evaporated we may be
ned is attained. The percentage strength of the residue
ary barometric pressure, according to the following table,
de on this subject by Roscoe and Dittmar. (Chem. Soc.

res	0·73	0·74	0·75	0·76	0·77	0·78	0·79
.	20·30	20·28	20·26	20·24	20·22	20·20	20·18

s where the barometer stands at about 0·76, the percentage
ng great error, be taken as 20·24. 180·3 grms. of such an
nt to 36·5 gr. of HCl.
ric acid of known specific gravity is so far diluted with water
than 36·5 gr. HCl. In a measured quantity (V c.c.) of this
dissolved in the cold in the proportion of 53 milligrammes
A few grammes of sulphate of sodium are then added,
xpel the carbonic acid. The sulphate of sodium is added
ydrochloric acid.
ntains, besides the neutral salts, only the excess of acid

---

mining silver has recently been investigated by Mulder (see Mulder,
, Leipzig bei Weber). He has made the singular observation, that a
ntities of Ag and NaCl-solution gives precipitates wth *both* reagents.
antity equivalent to $\frac{1}{2000}$ of the silver just precipitated is to be added,
tes ceases. Stass has, in the course of his determinations of atomic
on; but according to him, the limits of the state of indifferent equi-
ervations show that in order to attain the highest possible degree of
edure must be adopted.
s between twenty and thirty per cent. the relation between specific
en by the equation—

$$p = 200(s-1) + 0·3.$$

whose quantity has to be determined in order to find the strength of our test-aci
For this purpose the mixture is coloured slightly red with solution of litmus, a
an arbitrarily diluted caustic soda solution is added while the liquid is hot, till the la
drop causes a decided blue colour (without mixture of violet). The quantity
soda (t c.c.) required to produce the effect is noticed.* On the other hand, a fix
volume (v) c.c. of the test-acid is measured, and in exactly the same manner, t
quantity (t^1 c.c.) of caustic soda required for its neutralisation is determined.

From the last test, we have found that 1 c.c. of the arbitrarily diluted soda is equ
valent to $\frac{v \text{ c.c.}}{t^1}$ of our acid. Hence we had previously added $\frac{t}{t^1} v$ c.c. more of this ac
than is necessary for the neutralisation of V. 53 miligrm. of carbonate of soda, i.
$\left(V - \frac{vt}{t^1}\right)$ c.c. of test acid would have exactly sufficed to neutralise the weigh
quantity of carbonate of sodium. If, accordingly, we dilute $\left(V - \frac{vt}{t^1}\right)$ c.c. of acid
V c.c., then 1 c.c. of the mixture will contain exactly 1 milligramme-atom of H
In most cases, however, it is better not to perform this dilution, but to note that 1 c
test-acid contains $\left(\frac{V}{V - \frac{vt}{t^1}}\right)$ 36·5 milligrammes of HCl.

3. *Test Sulphuric acid.*—It is not necessary to have this as well as the hydrochlo
test-acid. Nevertheless it has over the latter the important advantage of being who
non-volatile when boiled in dilute solution. It can be prepared according to t
method described for hydrochloric acid under (*c*).

4. *Test Caustic soda*, which is, volume for volume, exactly or nearly equivalent
the test-acid. Carbonate of sodium is rendered caustic in the ordinary manner, a
so far concentrated that the requisite strength is nearly attained. A small quanti
more of milk of lime is then added, the liquid allowed to cool (the air being exclude
and the clear liquid drawn off by a syphon. For the exact determination of its strengt
50 c.c. test-acid are poured into a porcelain basin, a few drops of litmus are adde
and then the soda-solution is poured in from a burette till the colour begins to deepe
A decided reaction is recovered by addition of 1 c.c. of test-acid; about 2 grms.
sulphate of soda are then added (if hydrochloric acid is being employed); the liquid
heated to boiling, and soda is again poured in, till the liquid exhibits a distinct bl
colour. The calculation of the result requires no explanation.

5. *Solution of Litmus.*—Powdered litmus is digested in the cold with twenty tim
its weight of water, the solution filtered, and so exactly saturated, that 1 c.c.
the litmus solution diluted with about 100 c.c. water, is turned decidedly red by $\frac{1}{20}$ c
of test-acid, and decidedly blue by the same quantity of test-alkali.

Acidimetry.—Free acids in aqueous solutions, if these be free from magnes
alumina, and the heavy metals, and are not deeply coloured, may be determined in
manner which will be sufficiently clear from paragraph 4. If hot solutions are use
the caustic soda may without injury contain a little carbonic acid. But if we a
compelled to work in the cold, in consequence of the presence of salts of ammonia,
because the acid to be determined cannot be prevented from evaporating by additi
of sulphate of sodium, caustic soda must be employed which is almost perfectly fr
from carbonate. But even in such case, the termination of the reaction is not so eas
recognisable as when the solution is warm. It is best detected by dropping in t
soda rather quickly and without intermission, till the liquid, after stirring, remai
distinctly blue for some seconds. The gradual change of this colour to violet is
evidence of the solution not being neutral. Such change depends upon the subseque
action of carbonic acid upon the litmus. In the determination of weaker aci
such as the organic, the same exactitude of reaction is not observed as occurs in t
determination of sulphuric, nitric, hydrochloric, and other strong acids. It must
also noticed that many substances somewhat modify the blue colour which is t
criterion of completed reaction. In presence of many substances, such as ammonia
salts, &c., the change of colour from red to blue does not occur so quickly and decide
as when these substances are absent; and in a few instances, as when acetic acid is p
sent, the real point of saturation is not reached until after the change of colour has tak
place. In order to render the analysis, in such cases as these, as accurate as possib
it is advisable to make a control experiment under the same conditions as occur in t
real determination. Thus, for instance, if the strength of an acetic acid be require
it will not be sufficient to make an analysis in the ordinary way, because the neutr
acetates of sodium and potassium have an alkaline reaction, and this will mask t
true point of saturation; it is best, therefore, to prepare a solution of acetic acid

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* The change of colour is best seen in a porcelain basin, or in a flask standing on white paper.

g a known quantity of standard sulphuric acid to excess of
determine how much standard soda-solution is necessary
ange of colour in this acid solution. The strength of the
mpirically determined with acetic acid, the real analysis
eference to hypothesis.

c alkalis and their carbonates are easily determined in a
s to the method given (2, *c.*) for the preparation of standard
on is unnecessary. If many such determinations are to be
ploy test-sulphuric (not hydrochloric) acid, and so to dilute
e test-acid, volume for volume. If ammonia is to be deter-
by soda must be performed in a perfectly cold solution.
ime, and their carbonates, are determined exactly as the
rochloric acid must be employed and no sulphate of sodium
ulphates of these earths are precipitated, and such preci-
reaction. If only a small excess of acid has been used, the
d lost by a boiling of short duration is very inconsiderable.
ot occur in the first analysis, it may be made to do so in a

ATION AND REDUCTION.—It is known that most ele-
proportions with oxygen or its substituents; that lower
verted into higher oxides or chlorides, by the direct or in-
r chlorine; and that these higher compounds often give up
chlorine when in contact with reducing agents. Amongst
f this kind, all those can be employed which occur quickly,
ion of the reaction may be recognised with distinctness.
ethods of volumetric analysis of this kind hitherto pro-
only the most important. These may be divided into
which permanganic acid is the oxidant,—(*b*) those in
t.

ACID:
.—If a solution of permanganate of potassium be added to
solution of a protosalt of iron, the $Mn^2O^8K^2$ gives up $\frac{5}{8}$ of
nverting it into sesquisalt, and is itself converted into a
um-salt of the acid added; *e. g.:*

$$8SO^4H^2 = 2SO^4Mn + SO^4K^2 + 5(SO^4)^3Fe^2 + 8H^2O.$$

r of the permanganic acid is continually destroyed as long
resent; but as soon as all the protoxide of iron is converted
rop of the reagent, even if the solution is very dilute, gives
ion. Hence it is clear that protoxide of iron may be
manganate of potassium. A convenient standard solution
out 8 grammes of the commercial crystallised salt in 1 litre
ution oxidises, according to the relative purity of the salt,
of iron present in the form of protoxide. On account of
e the solution gradually though slowly decomposes, a fresh
of the solution must precede every series of iron deter-
se, 0·5 grm. of pure iron (thin harpsichord wire is almost
in a great excess of pure dilute sulphuric acid, the air
luded. Mohr recommends the double salt, SO^4FeNH^4 +
air-dry salt does not oxidise in air: it contains $\frac{1}{7}$ of its
ion is then allowed to cool, and is diluted with water free
l 0·5 litres. Chameleon solution is added from a burette
of the last drop no longer disappears. From the result
many milligrammes of iron are oxidised by 1 c.c. of the
der now to determine the quantity of iron in a given sub-
stance as will contain about 0·5 gr. of iron is dissolved, if
ric acid; hydrochloric acid should be used only when it
the iron is dissolved as protoxide, the solution is diluted
d examined just as was done in the case of the standard
If the iron is present partly or wholly as sesquioxide, this
tion by boiling with zinc free from iron, be completely
toxide. The reduction may be considered complete when
completely or nearly colourless. If any metals such as
eby precipitated, they must be removed by quick filtration

may be accurate, it is necessary—1. That the solution be very dilute, in order that the yellow colour of the sesquioxide of iron formed may no interfere with the distinctness of the reaction. If hydrochloric acid be present, more water than usual must in general be added, because in concentrated solutions, hydro chloric acid reduces permanganic acid.

$$Mn^2O^7 + 14HCl = 7H^2O + 10Cl + 2MnCl^2$$

2. An excess of acid—if possible, of sulphuric acid—must be present. The object o this is not only to make the colour of the sesquioxide of iron faint, but also to prevent the oxygen of the air and the small quantity of air in the water used for the dilution, from exerting an oxidising action during the operation.

It is scarcely necessary to mention that protoxide of iron may in this manner be determined in the presence of sesquioxide. The principal advantage of this determination consists in the fact that the presence of many substances, which often greatly complicated weight-analyses, does not interfere with its simplicity and accuracy. Even the iron contained in ferrocyanides may be determined by means of permanganate o potassium.

The behaviour of permanganic acid towards protoxide of iron may serve for the indirect estimation of many substances which are capable of oxidising proto-salts o iron. It is only necessary to allow the substance to act upon a known quantity o iron in excess dissolved as protoxide, and to estimate the amount of protoxide unacted upon, in the manner just described. Free chlorine, the active chlorine in chloride o lime, the higher oxides of manganese*, nitric acid, &c., may be determined in this way. We shall subsequently discuss other and better methods of estimating these substances, and will not therefore here enter into further particulars.

2. *Determination of Copper.*—The solution of the substance in water or nitric acid is mixed with a quantity of tartrate of potassium and sodium sufficient to prevent precipitation by the subsequent addition of an excess of caustic potash. The alkaline liquid is heated to boiling, and milk-sugar is added, till all the copper is precipitated as suboxide. This is collected on a filter, washed with hot water, and digested together with the filter, in strong hydrochloric acid and chloride of sodium. The resulting solution of $2NaCl + Cu^2Cl^2$, is to be diluted and treated with permanganate of potassium, as in the determination of iron. The filter, if the operation be quickly performed, has no action upon the permanganic acid. Since in this reaction 4 atoms of copper take up one atom of oxygen from the permanganic acid, every volume o our solution will oxidise as many atoms of copper (31·7 grms.) as it does of iron (28 grms.).

$$5Cu^2O + Mn^2O^7 = 10CuO + 2MnO$$

and

$$10FeO + Mn^2O^7 = 5Fe^2O^3 + 2MnO.$$

3. *Determination of Oxalic acid.*—When oxalic acid and permanganic acid are brought together in acid solutions, the former is oxidised to carbonic acid, the latter reduced to protoxide of manganese, which unites with the acid present:

$$Mn^2O^7 + 5C^2H^2O^4 + 2SO^4H^2 = 10CO^2 + 2SO^4Mn + 7H^2O.$$

Hence oxalic acid may be determined by means of permanganate of potassium in a dilute solution containing an excess of free sulphuric acid, in a manner exactly similar t that described under iron. For the determination of the permanganic acid, either pure air-dried, crystallised oxalic acid, $C^2H^2O^4 + 2H^2O$, or pure iron, is employed. A volume of test-solution which oxidises x atoms (x . 28) of iron, will convert $\frac{x}{4}$ atoms of oxalic acid (x : 31·5) into carbonic acid and water.

The behaviour of permanganic acid towards oxalic acid may be employed for the valuation of commercial peroxide of manganese: 1 grm. of the *very finely* powdered peroxide is mixed with a weighed quantity (about 1·5 gramme) of crystallised oxalic acid and a considerable excess of pure dilute sulphuric acid, and warmed till the peroxide of manganese is decomposed. Water is added, the solution allowed to cool and the excess of oxalic acid determined as above: 1 atom of peroxide of manganese transforms 1 atom of oxalic acid into carbonic acid:

$$MnO^2 + C^2H^2O^4 + SO^4H^2 = SO^4Mn + 2CO^2 + 2H^2O.$$

(*b*). METHODS IN WHICH IODINE ACTS AS OXIDISING AGENT.—Iodine in aqueous solution, in presence of oxidable substances, often acts upon the elements o water so as to form hydriodic acid with its hydrogen, while the oxygen acts upon the substance present. Now as the smallest quantity of free iodine may be recognised by its property of blueing starch-solution, whereas hydriodic acid and the iodides are without action upon starch, the substances mentioned may often be determined by mixing their

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[*] The determination of nitric acid becomes exact only when the reaction takes place in an atmosphere of hydrogen, but this precaution being taken, N^2O^5 oxidises exactly 12Fe. (Fresenius.)

olution, and then adding a standard solution of iodine
ermanent blue coloration occurs. In order that this
tance to be oxidised must, even in very dilute solution,
orising the iodide of starch which has been locally
rminations of this kind, we will take the following.
assium-, or sodium-salt, in neutral or alkaline solutions
tes of the alkalis), acts upon iodine in such a manner
d metallic iodides are produced, *e.g.*:

$$a^2 + 2I = 2NaI + S^4O^6Na^2.$$

f an alkali-salt, is converted by iodine into arsenic acid,
lkaline by carbonate or bicarbonate of an alkali-metal.
odide of starch formed is no longer decolorised on the
ium; 4 atoms of iodine (508 pts.) oxidise 1 atom of

$$+ 4I + 2H^2O = 4HI + As^2O^5.$$

rmined like hyposulphurous acid in solutions rendered
arbonate. The product formed is sulphuric acid:

$$2I + 2H^2O = 2HI + SO^4H^2.$$

free sulphurous acid by iodine, very divergent results
on is strong. In such cases, the quantity of sul-
phuric acid varies very much, according to the quantity
y with which the iodine is added. If, however, before
is so far diluted with water free from air, that less than
tained in 1 litre of water, the reaction, 2I + 2H²O +
ith perfect regularity.
hich this reaction takes place, were determined by
xvi. 265), and applied to a series of very accurate volu-
important of which we shall here explain.

eans of Iodine and Sulphurous Acid.

f potassium. 2. Pure hydrochloric acid. 3. Freshly
-solution.* A dilute solution of iodide of potassium,
oric acid, must give a mixture which remains colourless

dine in iodide of potassium, 5 grms. of commercial
dide of potassium, are dissolved in about 20 c.c. water,
dissolved the solution is diluted to 1 litre.
cid in distilled water. This must be so diluted that
sary to decolorise 1 volume of the iodine-solution (4).
 in quantities of 10 to 20 litres, and allowed to stand
e air, before use, so that the oxygen contained in the
by the sulphurous acid. It may be advantageously
provided with a tap at the bottom, and a fine drawn
r to enter. The strength of such a solution may be
e performance of one analysis.
ine *exactly* the strength of the iodine-solution, already
ad a small quantity of perfectly pure iodine of known
e by comparing such iodine with the standard-solution
ous acid. Such a quantity of iodine to serve as a
 between 200 and 400 milligrammes (= *A*) of pure
um with fuming hydrochloric acid, and collecting the
 iodide of potassium (for one part of the bichromate
ium are employed). 1 atom (294·8) of bichromate
ces 6 atoms of iodine (6 × 127·0):

$$l = 7H^2O + 2KCl + Cr^2Cl^6 + 6Cl$$
$$l + 6KI = 6KCl + 6I$$

n without loss, the following method is adopted.
mm. internal diameter, a bulb of about 30 c.c. capacity
tained of the form shown in *fig.* 48. To a short piece
d narrower tube is fused, drawn out at *d*, and bent as
k of the flask and the adapter-tube be ground flat and
ch a manner as to bring them close together, an appa-

---

saturated with chloride of sodium, may be kept a long time with-ratus is obtained for the evolution of chlorine, which is scarcely inferior to one sisting wholly of glass. The caoutchouc tube before use must be freed from adh sulphur by boiling with very dilute caustic soda and thorough washing with wat

A retort of about 150 c.c. capacity (*fig.* 49) serves to hold the solution of iodi potassium. The neck of the retort is widened at *a*, to receive any solution d back by the expelled air. In order to make the determination, we bring th chromate of potassium into the flask, which is then filled to $\frac{2}{3}$ with fuming h chloric acid; the delivery-tube is attached, and placed so far in the retort (fill to the commencement of the neck with iodide of potassium solution), that the chl which is not immediately absorbed must collect at *b*. The flask is first gently h till the decomposition is complete, then more strongly, in order to drive over trace of chlorine into the iodide of potassium solution by means of the gaseous and hydrochloric acid. The retrogression of the iodide can scarcely take pl some care is taken, because it can only occur very slowly, in consequence of the volume of the apparatus and the fineness of the point *d*. After the hydrochloric vapours have been evolved for about five minutes, it may be assumed that a chlorine is expelled. Without discontinuing the boiling, the delivery-tube is drawn from the retort, and the vapours are conducted into some fresh soluti iodide of potassium, the boiling being continued for a few moments longer. If solution remains uncoloured, the operation may be regarded as successful.

The contents of the retort (coloured deep brown by iodine) are quickly cooled poured out into a beaker glass, and portions of 400 to 450 c.c. of the dilute sulph acid are successively added, wi loss of time, until the liqui colourless. The measurement o sulphurous acid is effected in a which contains, up to a mark o narrow neck, from 400 to 450 but whose capacity need not b curately known. The flask is r out with the sulphurous acid, up to the mark, and emptied definite manner, which shoul strictly adhered to during the analysis. Direct experiments shown that the volume of the l delivered is sufficiently constan

The liquid decolorised by phurous acid contains an exce this body. Starch and then n iodine-solution are therefore till blue coloration occurs. Le volume of the latter necessar this be t^1 c.c. Immediately wards, one of the measures of phurous acid previously employ taken, and the volume (t c. standard iodine-solution deter which is necessary for its oxidation. If, then, the number n of the flasks o phurous acid which were added to the iodide of potassium solution from the has been noted, the strength of the normal solution may be easily calculated.

Fig. 48.

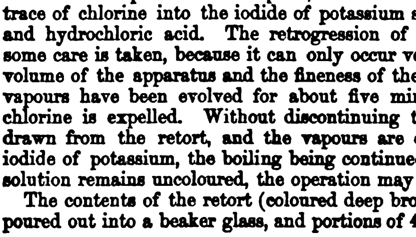
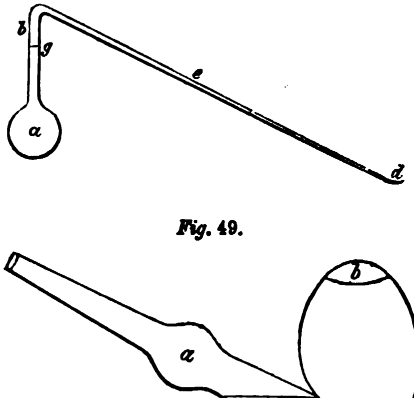


Fig. 49.



Let us call, for brevity, the contents of the flask the "volume." From the of the determination just given, we find that nt c.c. normal iodine-solution necessary for the oxidation of n volumes sulphurous acid. For such oxidation, of the same iodine-solution, together with the quantity of iodine produced b distillation of A milligrammes of bichromate of potassium with hydrochloric acid, also sufficient. This amount of iodine $\left(A. \frac{3 \times 127}{147 \cdot 4}\right)$ millg. is therefore equiv to $(nt - t^1)$ c.c. of iodine solution. Hence 1 c.c. of the latter contains

$$\frac{A \times 3 \times 127}{147 \cdot 4\,(nt - t^1)} \text{ milligrammes of free iodine, or}$$

$$\frac{A \times 3}{147 \cdot 4\,(nt - t^1)} = T \text{ milligramme-atoms of free iodine.}$$

Inasmuch as all subsequent analyses depend upon these determinations, the l must be performed two or three times, and the mean taken of the results (which s

ious analyses may be performed by means of an exactly
We will take the following examples.
phurous, *hyposulphurous*, and *arsenious* acids has been

ay be determined similarly to sulphurous acid, in a
4 grm. in 1 litre; but from some unexplained cause the
exact. The reaction which here occurs is represented
$2HI + S$.
ine, *Bromine*, and *Chlorine*. Iodine dissolves directly in
m; bromine and chlorine form bromides and chlorides,
ine. The quantity of the latter is determined by adding
lumes), then starch, and finally solution of iodine (t^1 c.c.),
occurs. If now t c.c. of iodine solution were necessary
of sulphurous acid, the liberated iodine must be equi-
tion, or the chlorine, bromine, or iodine must have the
ne-atoms.
rides of Chlorine which contain less than five atoms of
orine. All these substances are decomposed by iodide
acid in the following way:

$$+ 2xHCl = xH^2O + 2(x + 1)Cl.$$

d according to (3). Commercial bleaching powders are
chlorine which they contain, by treating them with an
and enough hydrochloric acid to cause a slightly acid
chlorine liberates an atom of iodine:

$$HCl + 4KI = 2CaCl^2 + 2H^2O + 4KCl + 2I^2.$$

Bunsen's experiments, these salts when distilled with
up free oxygen, but only free chlorine and lower oxides
of distillation be received in excess of iodide of potas-
eration of 6I for ClO^3H. Such iodine may be deter-

e iodic acid decomposes with 5 atoms of hydriodic acid
toms of free iodine ($HIO^3 + 5HI = 6I + 3H^2O$).
the determination of iodic acid. On the other hand,
be conveniently employed for determining the strength
(Bunsen.)
a portion of their oxygen in such a state that it liberates
rine on boiling with strong hydrochloric acid, may be
ith fuming hydrochloric acid, collecting the chlorine in
rmining the iodine set free according to (3). To this
higher oxides of manganese, chromic acid, and other
nalysing manganic oxides, a weak hydrochloric acid of
tionally) be employed, because on using fuming hydro-
escape. The calculation scarcely needs any explanation.
if we retain the usual symbols, amounts to $(nt - t^1)T$
s number of atoms of active oxygen are therefore
nown simple numerical relation to the number of atoms
ned.
y be peroxidised by chlorine, are determined by boiling
bichromate of potassium and hydrochloric acid, receiving
e of potassium solution, and determining it according
calculation, let us take the determination of protoxide
ichromate of potassium employed be A milligrammes;
), if iron had been absent, would have liberated $\frac{3 \, . \, A}{147{\cdot}4}$
ne. If instead of this, we actually find only $(nt - t^1)\,T$

$$\frac{3 \, . \, A}{147{\cdot}4} - (nt - t^1)\,T$$

must have served for the oxidation of the iron. Or:

$$\frac{A}{4} - (nt - t^1)T \Big\} . \, 2 \times 28$$

e been present.

---

in this reaction (and its *entire* absence has not yet been proved), the
ld not give accurate results. Bunsen, in his Memoir, gives only
ssium, which, however, agrees very well with theory.

Having become acquainted with the most important volumetric methods we now consider a point in connection with the calculation of the results. If a long s of determinations of the same kind have to be performed successively, the time ne sary for their calculation is of great consequence, and it is important to consider best way of simplifying it as much as possible. This may generally be effected b choosing arbitrary magnitudes which occur in the calculation, as the weight of substance, the strength of the normal solution, &c., that the mathematical expressior the result may be as simple as possible. The following examples will illustrate th

1. A number of soda determinations have to be made with an acid which cont 1·017 milligramme-atoms of sulphuric acid ($SO^4H^2 = 98$) in 1 c.c. If a milligran of soda be employed in the analysis, and if the volume of the acid used in neutralis be k c.c. then the soda contains $\frac{k \times 1{\cdot}017 \times 62 \times 100}{a}$ *per cent.* of anhyd soda (Na^2O). If now 1·017 × 62 × 100 milligrammes of soda be weighed each t then the fraction $\frac{1{\cdot}017 \times 62 \times 100}{a}$ is = 1, and the percentage of the soda in ca soda is = k, that is, simply equal to the number of c.c. of the standard acid used.

2. In the previous division (8), we have considered the determination of iror means of iodine-solution and sulphurous acid. If ϵ milligramme of the iron compo be employed for the analysis, the percentage (x) of iron is derived from the formu

$$x = \frac{2 \times 28 \times 100 \left\{ \frac{3\,A}{147{\cdot}4} - (nt - t^1)T \right\}}{\epsilon}$$

in which the letters have the signification before given. It is clear that the calcula is considerably simplified if (1) T be a round fractional number, for instance, (2) if A be made a simple multiple of 147·4, for instance, 5 × 147·4 milligramm (3). By taking ϵ so as to be a simple submultiple of 2 × 28 × 100, for insta 30 × 28 milligrammes.—W. D.

ANALYSIS (VOLUMETRIC) of GASES. This branch of analysis of late attracted much attention from chemists; but the chief improvements and velopments relating to it are due to Professor Bunsen. Previous to his resear on the subject, the processes adopted for measuring and analysing gases were so ceedingly imperfect, the inaccuracies introduced so numerous, and even the reag made use of so defective, that only the most variable results could be obtained; on the contrary, gases may be analysed with an accuracy which cannot be equa in any other branch of chemistry. So far indeed as accuracy and simplicity of m pulation are concerned, Bunsen's method leaves little to be desired; but it is long tedious, even a simple analysis requiring some days for completion. The neces calculations for the reduction and correction of the observations are also numerous require considerable time and attention.* To obviate these inconveniences, sev methods have of late been proposed, by which the composition of a gas may be a rately determined in a very much shorter time, and without the calculations form necessary.

The arrangement of the subject adopted in this article is: first a description of apparatus and general method proposed by Bunsen; then that of the more recent expeditious methods; and lastly, the processes, which to a certain extent are com to all the methods, for separating and estimating the different gases.

According to the method of Professor Bunsen, the gases are collected and measu in graduated tubes over mercury. For this purpose, two straight glass tubes are u one of them, which should be about 250 mm. long and 20 mm. in diameter, is termed absorption-tube, and the other which is from 500 to 600 mm. long, and 20 mm diameter, is termed the eudiometer (*figs.* 50, 51). The absorption-tube is vided with a sort of lip as shown in the figure, to enable the operator to pass the easily out of this tube into the eudiometer. As this latter tube is the one in which combustible gases are exploded, two platinum wires must be fused into the closed of it, for the passage of the electric spark. This is done by strongly heating the en the tube in the blowpipe lamp, and then just touching it at the point where the wi to be introduced, with a hot platinum wire; to this the glass strongly adheres, and this means is drawn out to a fine thread, which, on being cut off close to the eudiome is found to be hollow; through this hole a platinum wire is introduced, and the g carefully fused all round it. A second platinum wire is then by similar means fused the opposite side of the eudiometer. These wires should not project straight across tube, as they are then apt to become bent and moved from their proper dista h mercury;—if straight, they would also prevent the rly cleaned: it is consequently most convenient to have st the rounded top of the eudiometer. The ends of the nce apart of about 1 to 2 m.m. In order to ascertain properly fused in, so that the con- s may be perfect and no probability diometer is filled and inverted in a le held in a vertical position, sharply e trough; this communicates a move- oe, which sinking for a moment leaves on if the wires are not fused in abso- l bubbles will be seen rising from the

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* For a more detailed account of Bunsen's method of analysis, and for further informatio gasometry in general, we would refer the reader to Bunsen's "Gasometry," translated by Ro (Walton and Maberly.)

Fig. 50.

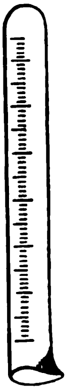
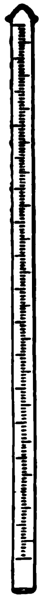


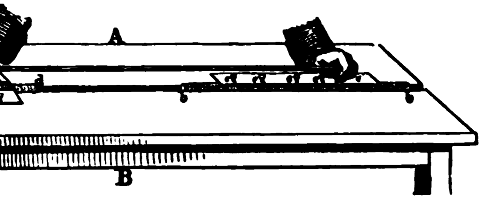
Fig. 51.



be air-tight, the next operation is to c acid, a millimetre scale on it and may easily be done by the following sted by Professor Bunsen. The tube the temperature at which bees-wax by means of a stick which passes e open end of it. The tube is then ble with melted wax, which is best er with wax, by means of a brush ng, it should be continually turned p the wax equally distributed over the hen cold is found to be completely ady for etching.

ratus used for this purpose, A B is a groove running along it of such size will lie easily in it; *d d* represents d in its place by two brass plates *e e*, e other end of the groove, a standard means of a brass plate, and on this e exactly copied on the wax covering means of a long bar of wood, to one oint, and to the other a kind of knife. s shown in the figure, the right hand the apparatus, the steel point is he divisions on the standard tube, hed, and while it is held there, a cut is made by means g the tube. The length of this cut, and the consequent ated by the distance between the two brass plates *e e*. has been made, the wooden rod is gently moved a

Fig. 52.

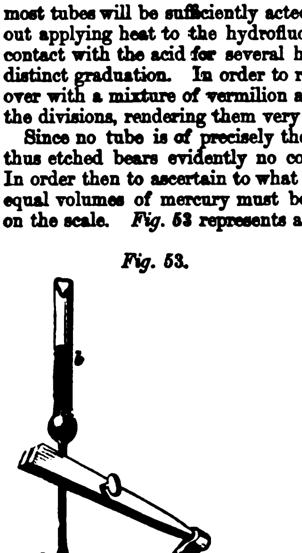


; falls into the next mark on the standard tube; then wax, and so on. The steel point should always rest ich will then serve to keep it in the same straight line. of the scale more easy, it is convenient to have every he others; which is easily accomplished by having slits t the distance of 5 mm. apart, so that when the knife it passes further across the tube than in other cases. e, it must be carefully examined, and if any false strokes ved by applying a thin heated wire to the spot: then, sh stroke may be made. The tube is now removed, and s indicating the number of millimetres from the top are s of a needle. If any of the wax has been removed from e brass plates, these places must be carefully re-covered, be exposed to the hydrofluoric acid.

This is most conveniently done in a kind of long narrow leaden dish. Powd fluor-spar is strewed along the bottom, and a large excess of sulphuric acid ad heat may then be applied. As soon as the gas comes off abundantly, the lam removed, the tube laid over the dish resting on two wire supports, and the whol covered with a sheet of paper. When the tube has remained there about three min it should be removed and one of the divisions examined by passing the nail ove to ascertain to what extent the etching has taken place. In from three to six minu most tubes will be sufficiently acted on. The etching may also be accomplished w out applying heat to the hydrofluoric mixture; in this case the tube must be le contact with the acid for several hours. This latter method yields perhaps the r distinct graduation. In order to render the scale still more clear, it should be rub over with a mixture of vermilion and copal varnish, which fills and hardens in eac the divisions, rendering them very evident to the eye.

Since no tube is of precisely the same diameter for any length together, the s thus etched bears evidently no constant relation to the cubic capacity of the t In order then to ascertain to what extent the capacity varies in different parts of t equal volumes of mercury must be poured into it, and the space they occupy read on the scale. *Fig.* 53 represents a convenient form of apparatus for always obtain these equal volumes of mercury. *a* is a small g tube fixed in a handle and capable of contai about that amount of mercury which is require fill the eudiometer through 20 mm. of its len *c* is a glass plate, on the top of which the two e of a strip of caoutchouc are fastened by sealing w so as to form a loop which is slipped over thumb. By turning the stopcock, which allows mercury to flow from the reservoir *b*, the g measure, the top of which must be ground perfe even, is completely filled, and the mercury r in a curve above the top; on depressing the pla the excess is expelled and the tube obtained fectly full: care must, however, be taken tha bubbles of air remain adhering to the sides. filling the measure, it is well to allow the en the tube *e* to rest on the bottom of it, and gradually to withdraw it when nearly full of m cury. The tube to be calibrated is firmly hel a perpendicular position by means of a clamp, the measures of mercury are then carefully pou in, any bubbles of air which may remain adhe to the tube, being removed by means of a small s or piece of whalebone. After each addition mercury, the height which it occupies on the sca read off. In order to prevent errors from paral this should be done by means of a telescope faste to a clamp which moves on a perpendicular supp In all readings-off, it is the position of the hig part of the mercury meniscus on the scale that is observed. This process for de mining the cubic capacity of the tube should always be gone through twice, and mean of the two series of observation taken as the basis of calculation. An exan will best show how these calculations are made and the results tabulated. The hei of the mercury in the tube after the successive additions of the measured quantity

Fig. 53.



	diff.
9·1	
	— 13·9
23·0	
	— 13·6
36·6	
	— 13·55
50·15	

In the second column is expressed the height which this constant quantity of m cury occupied. This varies of course with the capacity of the tube, increasing as tube diminishes, and diminishing as the tube increases in size. One of these differen generally the largest, is taken as the standard, say 13·9, that is, 13·9 volumes of m cury have been found to occupy on the scale:

mm.
1 × 13·9 – 9·1
2 × 13·9 – 23·0
3 × 13·9 – 36·6
4 × 13·9 – 50·15

s of the scale at these particular points, and it only
pective values of each division between these successive
e, between 9·1 and 23·0, each millimetre will represent
but in the second instance, where the 13·9 vols. of mer-
13·6 mm. where the tube in fact is broader, each division
9
= 1·022, and this number represents the capacity of
6
and 36·6. Again the capacity of each division between
1·025. In this way is formed a table, which, although
ly correct, the amount of error arising from the alteration
n each reading-off of the height of the mercury, being
e measured quantity does not extend over more than
g table is calculated from the foregoing observations.
ons on the scale are given, in the second their arbitrary

24	28·82	39	44·17
25	29·84	40	45·20
26	30·86	41	46·23
27	31·88	42	47·25
28	32·91	43	48·28
29	33·93	44	49·30
30	34·95	45	50·33
31	35·97	46	51·36
32	36·99	47	52·38
33	38·02	48	53·41
34	39·04	49	54·43
35	40·06	50	55·45
36	41·10	5	
37	42·12	52	
38	43·15	53	

st point of the meniscus of the mercury that is read off
ng the tube and afterwards in measuring the amount of
orrection must be applied to every observation to correct
wise arise from the convexity of the mercury. By re-
y be seen how this error arises. (1) In calibrating the
niscus, it is the number on the scale coinciding with the
ough the tube is not full up to that point by the space
a gas, when the tube is in the reverse position, the same
be read off, although the meniscus of the mercury only
n', leaving in fact a space as much below *c c'* unoccupied
as was left above it in the former one. Hence after re-
in the relative value of any reading-off, there must be
o the whole space *a n a' n'*. What this number is, which
easily be ascertained by the following process. The
perpendicular position with its closed end downwards, a

small quantity of mercury is poured into the tube, and its height carefully n
a few drops of a dilute solution of corrosive sublimate are now added, the eff
which is entirely to destroy the meniscus, and render the surface of the me

Fig. 54.

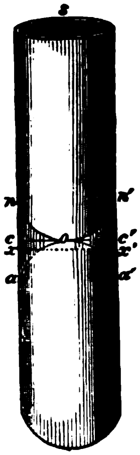
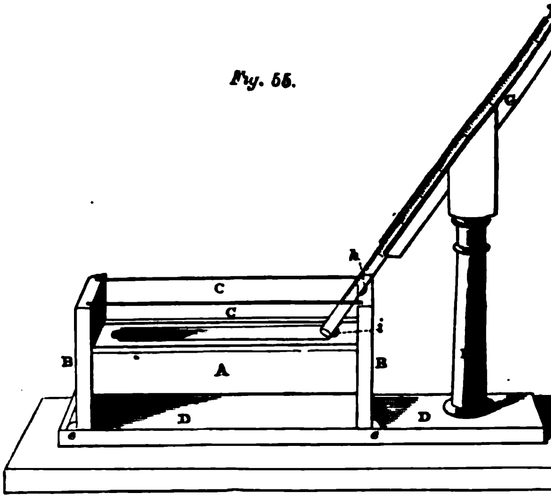


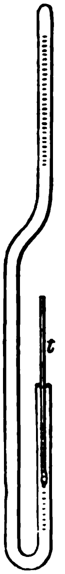
Fig. 55.



perfectly flat: the height $x\,x'$ at which it now stands in the tube is read off. Twic
difference of these two readings is then the quantity to be added to each observ
after referring to the table of capacities.

The most convenient form of mercury-trough is that proposed by Bunsen,
represented in *fig.* 55. It is about 350 mm. long, and 80 mm. broad. The two
C C, are made of thick glass plates, and the lower part of it A, is formed out of a s
piece of wood hollowed out. In order to economise the amount of me
necessary, the inside of the trough is made round at the bottom inste
being square. G forms a convenient support for the eudiometer. B
using the trough, it should be well rubbed with corrosive sublimate
mercury, or else small bubbles of air are apt to remain adhering to the w
and may afterwards rise into the eudiometer.

Fig. 56.



A good thermometer and barometer are of course indispensable.
length of the degrees on the thermometer scale should be such that
position of the mercury, to a tenth of a degree centigrade, may be e
read off by means of the telescope. The barometer generally used
the syphon form (*fig.* 56). The scale is etched on the glass and
closed end is bent as shown in the figure, so that the scale on the two l
is in the same straight line. The thermometer *t*, is placed in the
end of the barometer, and held in its place by a small piece of whalel
which acts as a spring. Before reading off the height of the barometer
thermometer, the latter should be gently moved a little up and down,
communicating to the mercury in the barometer a slight movement, w
overcomes any adhesion between the mercury and the glass.

The kind of room which is used as a gas-laboratory when this pr
is adopted, is a point of very considerable importance. It should ha
northerly aspect, and the walls should be thick; in fact, the room mu
protected in every way from sudden changes of temperature. The me
trough and barometer should stand on a table immediately in front
window, if possible a double one. The table is provided with a rim r
it, in order to prevent the loss of any mercury that may happen to be
upon it. Between every two operations in the analysis, at least half an
must be allowed to elapse, in order that all parts of the apparatus may retu
the temperature of the room. Great care must be taken in filling th
diometer and absorption-tube with mercury, that no air remains adheri
the sides of the tube. This is most easily avoided by introducing the me
through a funnel, to which is attached a narrow glass tube reaching
nearly to the top of the eudiometer; the mercury then rises gradually, the funnel l

very thoroughly from the tube. A small bubble of air ound to remain in contact with the platinum wires in the ot rid of by placing the thumb over the open end of the inclined position; then, by means of a sudden jerk, the om the wires, and by merely inverting the eudiometer,

fore stated, are made with the help of a telescope, which ven or eight feet from the tubes. Care should always be oe read off is nearly in the middle of the field of the tele- y arise from parallax. It is therefore convenient to have a cross wire.

lysis, four observations have to be made: 1st, the height tube; 2nd, the height of the mercury in the trough as measured on the scale of the gas-tube; 3rd, the temperature; and 4th, the atmospheric pressure. The barometer and thermometer are always read off last; for before doing this, it is necessary to approach the table in order to move the thermometer, as before described, and the heat given out from the body would increase the volume of gas in the tube. In order to read off accurately the level of the mercury in the trough, it is necessary so to place a piece of white paper between the glass side of the trough and the tube, that it may reflect the light from the window on to the scale. *Fig.* 57 shows how this is conveniently arranged, the scale being seen through the slit *m*.

After each operation in the analysis, before leaving the tubes to cool, a rapid observation should be made with the telescope, in order to see that the scale on the eudiometer is in its right position, passing apparently exactly through the highest point of the meniscus, and also that the height of the mercury both in and outside the tube can be easily read off.

In order to render the observations thus made at different temperatures and pressures comparable, they must be re- , the one generally employed being dry air at 0° C., and of mercury. If v represent the volume of gas as taken of the meniscus, b the height of the mercury in the gas- h, t° the temperature, and B the height of the barometer, give the corrected volume V', under the standard tempe-

$$\frac{m)(B - b)}{0{\cdot}00366t^{\circ})} = V'.$$

which must not be overlooked in the calculation, viz. the -vapour. If the gas is saturated with moisture, and the servation of its volume was made is known, it is then he table of tensions of aqueous vapour and extract the t temperature: this must be deducted from the height of rmula for the reduction of gases saturated with aqueous

$\frac{- T)}{t^{\circ}} = V'$, where T is the tension of aqueous vapour

ensure a gas being completely saturated with moisture, a duced into the eudiometer before filling it with mercury. early how these calculations are made, the following ex- Gasometry, is cited, of the measurement of the same d with moisture and afterwards dry.

		Moist.	Dry.
evel of the mercury . .		565·9 mm.	565·9 mm.
evel in the eudiometer .		317·3	310·7
o be subtracted from		248·6	255·2
10·7 correspond to the capacity . . .	V .	292·7	286·0
s	m	0·4	0·4
. . . . .	t	20·2 C.	20·2 C.
. . . . .	B	0·7469 m.	0·7474 m.
for 20·2 C. . .	T	0·0176 m.	

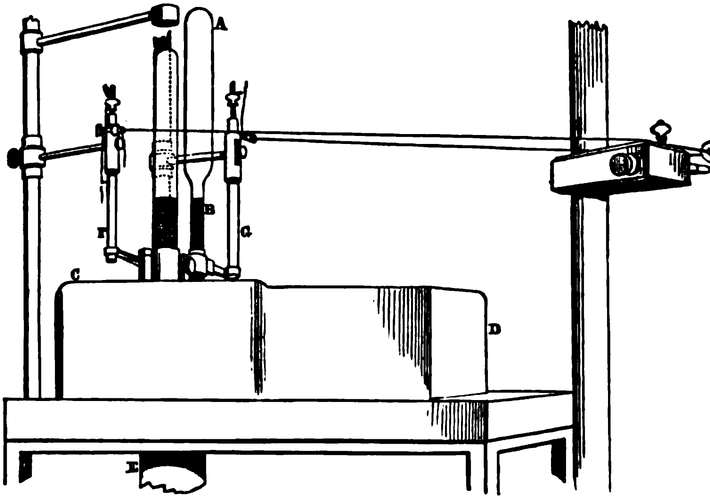
$$\begin{array}{rcll}\log.(V + m) & = & \log.\ 293{\cdot}1 & = 2{\cdot}46702 \\ +\ \log.(B - b - T) & = & \log.\ {\cdot}4807 & = 0{\cdot}68187 - \iota \\ +\ \text{compl. log.}\ (1 + 0{\cdot}00366t) & = & \text{compl. log.}\ 1{\cdot}0739 & = \underline{0{\cdot}96903 - 1} \\ & & \log.\ V' & \ 2{\cdot}11792 \\ & & V' & \ 131{\cdot}20. \end{array}$$

For the dry air we have:

$$\begin{array}{rcll}\log.(V + m) & = & \log.\ 286{\cdot}4 & = 2{\cdot}45697 \\ +\ \log.(B - b) & = & \log.\ 0{\cdot}4922 & = 0{\cdot}69214 - 1 \\ +\ \text{compl. log.}\ (1 + 0{\cdot}00366t) & = & \text{compl. log.}\ 1{\cdot}0739 & = \underline{0{\cdot}96903 - 1} \\ & & \log.\ V & \ 2{\cdot}11814 \\ & & V' & =\ 131{\cdot}26. \end{array}$$

A modification of Bunsen's method has been proposed by Messrs. **William** and **Russell** (Proceedings of the Royal Society, vol. ix. p. 218), whereby the e of any alteration in the barometer or thermometer on the gas during the anal is entirely eliminated: moreover, the gas operated on is always read off satur with aqueous vapour, so that no calculations are necessary for reducing volume to a standard temperature and pressure. The principle on which this sin fication depends is, that of always retaining the gas at the same degree of e ticity. If, for instance, a fall of temperature has occurred, then by diminishing pressure on the gas a certain amount, its elasticity will remain unaltered; and f rise in temperature, the pressure must be correspondingly increased to retain the at the same volume. This equally applies to any alteration in the barometer. means adopted for ascertaining exactly how much the pressure on the gas has t increased or diminished for any variations of the barometer or thermometer, is sin to introduce a standard quantity of air into a tube over mercury, and mark off height of the mercury on the tube, at the normal temperature and pressure; then any other temperature or pressure, by raising or lowering the tube in the merc trough, so as exactly to bring the mercury again to the same mark, the elasticit the air is maintained constant. The gas in the eudiometer is always read off at constant degree of expansion, and this is done merely by raising or lowering it in trough, until the column of mercury within the eudiometer is of exactly the s height as that in the tube containing the standard amount of air. *Fig.* 58 repres

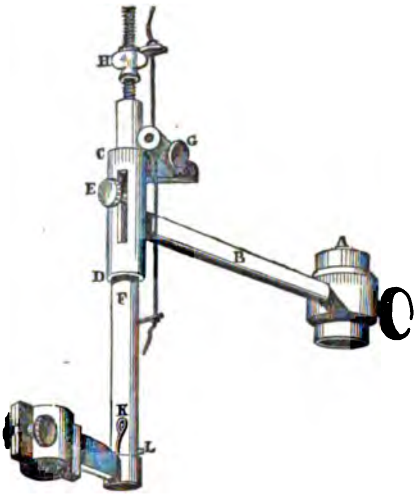
Fig. 58.



the apparatus used in this method. A B is the tube containing the standard amo of air, and is termed the "pressure-tube:" the upper part of it is six or se inches long, and of about the diameter of an ordinary Bunsen's eudiometer; the lo part B is of about the same length, but only $\frac{3}{8}$ inch internal diameter. Into this p sure-tube is introduced such a quantity of mercury that, when it is inverted in trough, the mercury stands at a convenient height in the narow tube; at this point, mark is made which indicates the height of mercury needed at any temperature or p

air to its original volume. The mercury-trough C D differs
being provided with a well E, at one end, in which the
or lowered so as to bring the gas it contains to the same
ressure-tube. Both the eudiometer and the pressure-tube
position by means of clamps F and G, which slide on up-
provided with a simple kind of slow movement, by which
lowered by the operator, whilst he is looking through a
nce.
w of one of the clamps, which shows more distinctly how
ced. A is the part which slides up and down the vertical
he inside
ch moves
the arm
me plane.
h the rod
a. E is a
l F in its
which the
through
pleasure.
l to C D;
e right or
or below
sequently
In order
may not
ses in the
six feet in
ese cylin-
carrying
ig. 58. H
r tighten-
so placed
hat when,
nd, it is
e tube is
applying
ading off. In operating with this apparatus, the pressure-

Fig. 59.



in front of the eudiometer, and the clamp moved up or
ne top of the mercury inside about coincides with the mark
n the same way, the eudiometer is so adjusted that the
is of about the same height as that in the pressure-tube.
wed on, and the whole allowed to cool.
eading off the amount of gas is, while looking through the
rod connected with the pressure-tube so as to bring the
mark on the stem, then raise or lower the eudiometer so
rcury inside it may coincide precisely with the meniscus in
s easily done, as the diameter of the pressure-tube is con-
t of the eudiometer, and the meniscus in the latter can be
f the meniscus of the pressure-tube. It is convenient also
ube, the stem of which should be about three times as long
described. By this means, when only a small amount of
can be read off at a greatly reduced pressure, and conse-
ate accuracy. In order to render the reading made with
le with those made with the second, it is only necessary to
of gas at each of these degrees of expansion, this at once
in which any amount of gas read off, at the greater degree
, will have to be diminished in order to render it com-
the lower degree of expansion. This method yields very
are obtained with less trouble than by Bunsen's method,
lculations.

us next to be described is that proposed by MM. Regnault
Phys. [3] xxvi. 333). Its peculiar advantage is, that
it with very much greater rapidity than is possible by
ously described, and also that it does not require a room to
s.

The economy of time is effected in two ways: first, by surrounding the gas-tub with water, which almost immediately causes their contents to assume the sa temperature as that of the external medium; secondly, by the use of liquid reage instead of solid, which are necessarily used in Bunsen's method.

The form and principle of M. Regnault's apparatus will be easily understood fr *figs.* 60 and 61. It consists essentially of two parts, which can be easily joined a

Fig. 60.

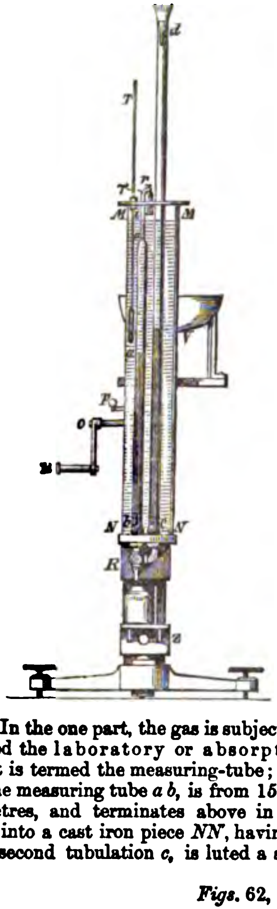
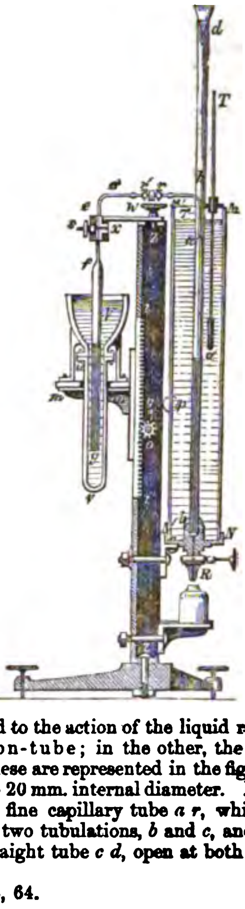
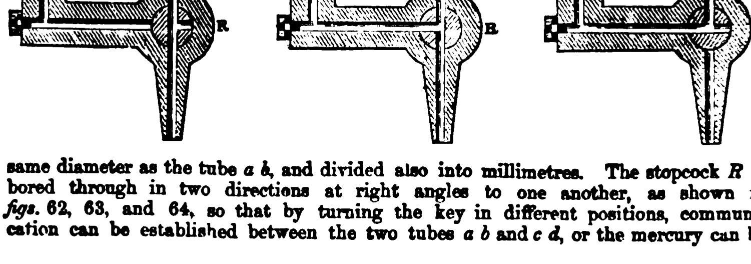


Fig. 61.



separated. In the one part, the gas is subjected to the action of the liquid reagents, a this is termed the laboratory or absorption-tube; in the other, the gas is me sured, and it is termed the measuring-tube; these are represented in the figures by *f* and *a b*. The measuring tube *a b*, is from 15 to 20 mm. internal diameter. It is divid into millimetres, and terminates above in a fine capillary tube *a r*, while the low end is luted into a cast iron piece *NN*, having two tubulations, *b* and *c*, and a stopco *R*. To the second tubulation *c*, is luted a straight tube *c d*, open at both ends, of t

Figs. 62, 63, 64.



same diameter as the tube *a b*, and divided also into millimetres. The stopcock *R* bored through in two directions at right angles to one another, as shown *figs.* 62, 63, and 64, so that by turning the key in different positions, commun cation can be established between the two tubes *a b* and *c d*, or the mercury can

r. These tubes are surrounded by a glass cylinder filled
thermometer T is immersed. During the analysis, the
e indicate a constant temperature; should any alteration
al temperature must be restored by the addition of hot or

fixed on a cast-iron stand z z, furnished with levelling-
be *g f*, is open at the bottom and terminated above by a
This tube dips into a small mercury
what is still better, gutta-percha,
more clearly the form of this trough.
a small iron bracket, which by means
ion *o*, to which the handle B is at-
and down. It is retained in any
to which, in order to facilitate its
and as this is turned from one side
thrown in or out of gear with the
capillary tubes, which terminate the
tube, are carefully luted two small
ds of which exactly fit each other,
ted in *fig.* 67, in section. In order
two as air-tight as possible, a little
ed to the faces *a b* and *a' b'*, which
tight as possible by means of a screw
8. The laboratory-tube is held in a
p *u*, which is lined with cork, and
red distance from *z z*, by means of
ng-tube *a b* is provided with two
ordinary eudiometer. The following
lt (Cours de Chimie, iv. 77) of an
r and carbonic acid will perhaps best
s used.
fill the measuring-tube: this is done
e tube *c d*, until it begins to escape
ich is then closed. The laboratory-
ng it into the mercury-trough *V*, the
fill the capillary-tube *f e r*, the best
he mouth to the open end of it and
close the stopcock. The tube being
y, it is fixed in its place and the
pcocks.
now introduced into the laboratory-
been lowered to such a position that
ube only reaches to a short distance
is then easily passed up into it. This being done, the
he mercury allowed to flow out of the measuring-tube, by
d over into the measuring tube. When the mercury reaches
opcock *r* is nearly closed, thus causing it to rise but slowly,
rcury arrives at a certain mark σ on the horizontal part of
pcock *r'*, is closed. The level of the mercury is thus
a, of the tube *a b*, and the difference of height of the two
read off on the scale of the tube *c d*. The water should
air into it through a tube which descends to the bottom of
f the thermometer and barometer must also be observed.
ation should be necessary for estimating the tension of
lways saturated with moisture; this is done by moistening
tube *a b*: the mercury, in passing through, merely removes
ways leaves a small quantity adhering to the sides of the
ture of the water, which, as before stated, must be station-
the tension of the aqueous vapour at this temperature; *v*
the height of the barometer; and lastly, *h* the difference
ury in the two tubes. $H + h - f$ is then the elasti-
Having thus measured the quantity of gas taken, the next
arbonic acid present. The trough *V* is again lowered and
te, a single drop of a strong solution of caustic potash is
tory-tube. Mercury is then poured into the tube *c d*, and
to establish communication between the tubes *a b* and *c d*,
r r', the gas is then forced back into the laboratory-tube.

Fig. 65.

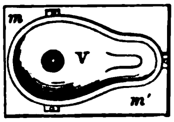


Fig. 66.

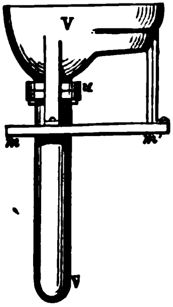


Fig. 67.

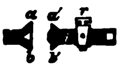
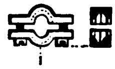


Fig. 68.



As the mercury in it sinks, the caustic potash moistens the sides of the tube, th
exposing a very large absorbing surface. In a few minutes, the whole of the carbo
acid is absorbed; and the absorption may be rendered still more speedy and certain,
raising the trough and opening the stopcock r, so that the gas may again be drawn i
the measuring tube and afterwards forced back a second time into the laboratory-tu
thus bringing it in contact with a fresh surface of potash. It has been shown that af
this operation has been repeated twice, no appreciable amount of carbonic acid rema
unabsorbed. As it is essential that none of the absorbing liquid should ever p
over into the measuring-tube, the error arising from an amount of gas remaining
the capillary tube $f\ e\ r'$, is best eliminated by always making this a constant quant
which is done by closing the stopcock r', when the column of liquid reagent or merc
arrives at a certain mark σ.

The absorption being completed, the level of the mercury in the tube $a\ b$ is ag
brought to the mark a, and the difference of height h' of the mercury in the two tu
$a\ b$ and $c\ d$, is read off. H′ the height of the barometer, is also noted. If the tem
rature of the water in the cylinder has changed, it must be restored to the origi
temperature t, by the addition of hot or cold water. The elastic force then of the
deprived of carbonic acid and dry, is $H' + h' - f$; and consequently $(H + h - f)$
$(H' + h' - f) = H - H' + h - h'$, is the diminution of elastic force, caused by
absorption of the carbonic acid; and $\frac{H - H' + h - h'}{H + h - f}$ represents the proportio
carbonic acid in the gas when dry.—The proportion of oxygen in the remaining
has now to be determined. The laboratory-tube is detached, thoroughly washed,
dried, first by means of paper, and afterwards by bringing it into connection with
air-pump. It is then again filled with mercury and fitted on to the measuring-tu
The trough U is now raised, and the stopcock R opened. On now turning the cocks
the mercury in the laboratory-tube passes into the capillary-tube $a\ r$, and is allowed
proceed as far as a given mark τ; when it reaches this mark, the stopcocks $r\ r'$ are clo
The mercury in the measuring-tube is then again brought to the point a, and
difference of the level h'' and the height of the barometer H'' read off. $H'' + h''$
is therefore the elastic force of the dry gas now in the apparatus, a small quan
(about $\frac{1}{3000}$) of the whole having been lost by detaching the laboratory-tube. T
second measurement prevents any inaccuracy thence arising.

A proper quantity of hydrogen is now introduced, and a uniform mixture of
whole produced by passing the gas two or three times backwards and forwards fr
the laboratory-tube into the measuring tube. When thoroughly mixed, the colum
mercury is again brought to the mark τ, and the gas in the measuring tube to
point a. The difference of height h''' of the two columns of mercury is read off,
the height H''' of the barometer. $H''' + h''' - f$ is therefore the elastic force of
mixture of hydrogen, oxygen, and nitrogen. The capillary-tube ra, is now c
pletely filled with mercury, so that none of the gas shall escape combustion, and
electric spark passed through the mixture. After the explosion, the stopcocks $r\ r'$
carefully opened and the gas subjected to a slight pressure, so that the mercu
forced back along the capillary-tube till it arrives at the point τ; the stopcocks
then again closed, and the gas expanded as before to the mark a. Its elasticity
now be represented by $H'''' + h'''' - f$. Consequently $(H''' + h''' - f) - (H''''$
$h'''' - f) = H''' - H'''' + h''' - h''''$, is the elastic force of the gaseous mixt
which disappeared during the combustion; $\frac{1}{3}(H''' - H'''' + h''' - h'''')$ is the ela
force of the oxygen contained in the dry gas, of which the elastic force was $H'' + h'' -$
and $\frac{1}{3}\,\frac{H''' - H'''' + h''' - h''''}{H'' + h'' - f}$ is the proportion of oxygen contained in the gas w
freed from carbonic acid, whence the proportion of oxygen in the original gas may
easily deduced.

As the gas is made to occupy a constant volume during the whole analysis,
entirely removes the necessity of calibrating any of the tubes. This apparatus m
however, be used in a different way, and then the calibrating of the tube $a\ b$ becor
necessary. In this case, instead of always bringing the gas to a constant volume
reading off the pressure it supports, the pressure is retained constant, and the differe
of volume read off. The calibration of the tube $a\ b$ is effected by filling it complet
with mercury, and then allowing a small quantity to flow out through the stopcock
collecting and weighing this, then reading off on the tube the height through wh
the mercury has fallen. The temperature of the water in the cylinder should be k
constant during the whole operation.

The apparatus of MM. Regnault and Reiset leaves but little to be desired w
regard to the rapidity with which analyses can be made; but this rapidity is to
certain extent obtained at a sacrifice of accuracy, considerable change in the bulk
gas operated on being represented by only a small change in the amount of pressu
In a comparison made by Messrs. Frankland and Ward, of the methods of Bun

n that an error of $\frac{1}{10}$ of a millimetre in the first obser-
nault's method an error in the percentage amount, seven
e the case when Bunsen's method was adopted. There is
ifficulty in maintaining the water in the cylinder at precisely
ny length of time together.

d **Ward** have constructed (Chem. Soc. J. vol. vi. p. 197)
or the analysis of gases, which, in mechanical construction
king
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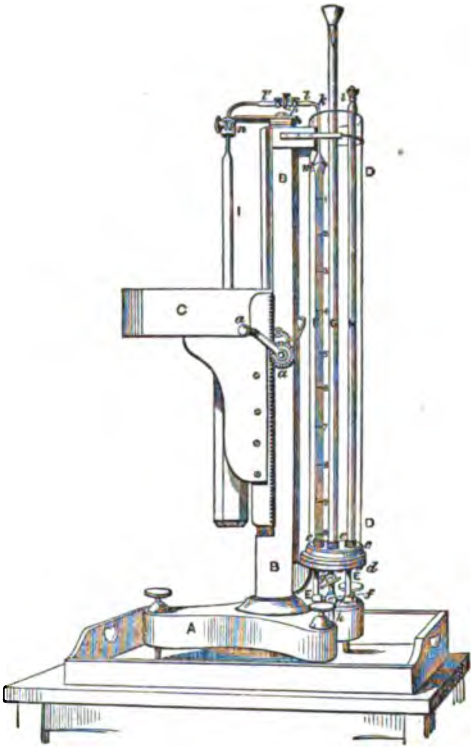
This
double-waycock *f*, and a single-waycock *g*, by means of
nto the sockets *e e e*, can be made to communicate with each
e *h* at pleasure." F, G and H are three glass tubes which
he caps *e e e*. F and H are each 15 to 20 mm. internal
difference in the capillary action, are selected of as nearly
The tube G is somewhat wider, and may be continued to
ove the cylinder. H is accurately graduated into milli-
t the top with a small funnel *i*, into the neck of which a
in diameter, is carefully ground. The tube F terminates
the capillary-tube *k*, which is carefully cemented into the
as also fused into it at *m* two platinum wires, for the passage
r this tube has been firmly cemented into the cap *e*, its in-
divided into ten equal parts. This is done first by filling
pply tube G, up to its junction with the capillary tube *k*, and
o run off through the nozzle *h*, until the highest point of the
sion 10 previously made, so as exactly to coincide with the
e on H. The weight of the mercury thus run off is care-
tube is again filled as before, and divided into ten equal
ury to run off in successive tenths of the entire weight, and
top of the meniscus after each abstraction of the metal,

Fig. 69.



by screwing a small copper ring on to the tube at that point. By using proper p cautions with regard to temperature, &c., an exceedingly accurate calibration can made in this way. In practice, however, it is found much easier to make the calib tion in the following manner. The ten copper rings are screwed on to the tube fi at about equal distances apart, but without any relation to the capacity of the tu which is afterwards ascertained by expanding the same volume of gas down to e of the ten divisions, and reading off the height of the column of mercury in the t H in each instance. The way in which the laboratory tube I is joined to the rest the apparatus is precisely similar to that adopted by MM. Regnault and Reiset, a already described.

When the instrument is thus far completed, it is requisite to ascertain the hei of each of the nine upper divisions on the tube above the lowest or tenth divisio this is very accurately effected in a few minutes by carefully levelling the instrume filling the tube G with mercury, opening the cock *l*, and the stoppered funnel *i*, a placing the cock *f* in such a position as to cause the tubes F H to communicate w the supply-tube G. On now slightly turning the cock *g*, the mercury will slowly r in each of the tubes F and H; when its convex surface exactly coincides with ninth division on F, the influx of metal is stopped, and its height in H accurat observed; as the tenth division on F corresponds with the zero of the scale upon it is obvious that the number thus read off is the height of the ninth division ab the zero point. A similar observation for each of the other divisions upon F comple the instrument.

Before using the apparatus, the large cylinder D D is filled with water, and inside of the tubes F and H are once for all moistened with distilled water, by introduction of a few drops into each, as in Regnault's apparatus. The three tu being then placed in communication with each other, mercury is poured into G u it rises into the cup *i*, the stopper of which is then firmly closed. When the merc begins to flow from *l*, that cock is also closed. The tubes F and H are now apparen filled with mercury, but a minute and imperceptible film of air still exists betw the metal and the glass: this is effectually got rid of by connecting F and H w the exit-tube *h*, and allowing the mercury to flow out until a vacuum of several inc in length has been produced in both tubes. By allowing the instrument to remain t for an hour, the whole of the film of air above mentioned will diffuse itself into vacuum, and will become visible as a minute bubble in each tube, on allowing vacuum to be filled up from the supply-tube G. By opening for a moment the stopp and the cock *l*, whilst G is full of mercury, these bubbles are expelled. The absorpt or laboratory-tube I being then filled with quicksilver, and attached to *l* by the scr clamp, the instrument is ready for use.

The method of introducing the gas, applying the absorbents, and passing the from one tube to the other, is in this apparatus so precisely similar to that adopted using Regnault's apparatus, and before described, that it need not be further dw upon. The method of reading off the amount of gas is, however, different, a requires a few words of explanation. When the gas has been passed over i the tube F, mercury is allowed to flow out of the stopcock *f*, until a vacuum of t or three inches in length is formed in H, and the metal in F is just below one the divisions; the cock *f* is then reversed, and the mercury very gradually admit from G until the highest point in F exactly corresponds with one of the divisions that tube; that this is really the case, must afterwards be ascertained by viewing through a telescope. The height of the mercury in the tube H is then read off. the division on the tube F, to which the gas has been expanded is, for instance, fourth, then, from the number read off on the tube H must be deducted the height this fourth division above the zero point of the tube. The remainder will express volume of the gas; but in order to compare this with subsequent readings made other divisions upon F, the number thus obtained, which represents the pressure of gas, is reduced to what it would have been had the gas been expanded to the ter division of F. This is very simply done, by merely multiplying the number rep senting the pressure of the gas by a fraction whose denominator is 10, and numera the number of the division to which the gas has been expanded; thus, in the case ab cited, the multiplier would be 0·4.

The following are the results of an analysis of air made by Messrs. Frankland a Ward.

Volume of air used. (Determined at fifth division on F.)

Observed height of mercury in H	673·0 mm.
Height of fifth division above zero	383·0
Corrected pressure of gas	290·0
	·5
Corrected pressure of gas at tenth division . . .	145·0

n of hydrogen. (Determined at sixth division.)
mercury in H . . . . . 772·3 mm.
ision above zero . . . . . 304·0
e of gas . . . . . . 468·3
·6
f gas at tenth division . . . 280·98

Determined at fifth division.)
mercury in H . . . . . 763·3
ion above zero . . . . . 383·0
f gas . . . . 380·3
·5
f gas at tenth division . . . 190·15

Results.

. . . . 145·00
. . . . 30·276

. . . . 79·120
. . . . 20·880
100·000

m of apparatus is to that of Regnault, and capable as
l rapid results, still there are defects in it which detract
alue. The principal of these is the great difficulty there
the apparatus in a perfectly air-tight condition, especially
o be joined and separated once or twice during an analysis.
has also been found to arise from the very fragile nature
even when full of mercury, is only supported by the
s fused, and consequently the slightest blow or pressure
eparate at this point of junction. Some difficulty is also
water in the cylinder at exactly the same temperature
e analysis. Regnault, as before stated, suggests adding
equired temperature is obtained; this is an operation
, and without much care is likely to lead to fallacious
proposed using a stream of water direct from the street
der at the bottom, and is allowed to flow off by an exit-
a great improvement upon Regnault's method, but even
variations occasionally occur.

principal forms of apparatus used in the analysis of gases,
methods to be adopted for the separation and quantita-
nt contituents which may occur in a gaseous mixture.
inity for any particular reagent, are estimated directly by
he absorption-tube; but since many gases are not absorb-
and indirect method has to be adopted, as for instance,
n is estimated by exploding it with oxygen and observing
nce ensuing.
which gases are estimated directly and which indirectly.
xygen and carbonic oxide, will be found in both lists, as
er method.

s estimated by the direct method.

drous).
ous).

Carbonic acid (anhydrous).
Oxygen.
Carbonic oxide.
Olefiant gas.
Nitric oxide.

Gases estimated indirectly.

Light carburetted hydrogen.
Ethyl.
Methyl.

The gases estimated by absorption may, for analytical purposes, be convenie divided into three groups.

1st Group: — *Hydrochloric acid; Hydrobromic acid; Hydriodic acid.* These absorbable by means of sulphate of sodium.

2nd Group: — *Hydrosulphuric acid; Sulphurous acid; Carbonic acid.* These absorbed by caustic potash, but not by sulphate of sodium.

3rd Group: — *Oxygen; Nitric oxide; Carbonic oxide; Olefiant gas.* These neither absorbed by sulphate of sodium nor by caustic potash. With regard to manner of applying the reagent, if the apparatus of Regnault or Frankland be a few drops of a very strong solution of the reagent are introduced into the laborat tube, by means of a bent pipette, as little of the liquid being used as possible, to vent any appreciable loss arising from its absorbing power. But in using Bun method, or that proposed by Williamson and Russell, the reagent must be introd in a solid form if possible, or if necessarily a liquid, some porous substance mu saturated with it.

Estimation of the Gases of the 1st Group.—The sulphate of sodium is i duced into the gas by first melting it in its water of crystallisation, and then dip into it the end of a platinum wire which has been bent into a short coil; this is repe several times until a ball of the sulphate of sufficient size is obtained. If mu these acids is believed to be present, the ball should be of a large size, or els sulphate of sodium is apt to become deliquescent, and run down the sides of the All aqueous vapour must also be carefully removed from the gas before introducin sulphate of sodium. This is best accomplished by means of a ball of phosphoric which may easily be made by dipping the coiled end of a platinum wire into hot l phosphoric acid; a drop adheres to the wire, and then as the acid cools the size o ball is increased to about that of a large pea, by turning it round in the viscous m mass. The thickness of the platinum wires used in these experiments should be that the balls of reagent may be easily pushed into the eudiometer without the bending. Great care must also be taken that the surface of the ball is as smoo possible, or adhering air will be introduced into the gas, and some of the gas rem on withdrawing the ball. Oxide of bismuth or zinc may also be used for abso the members of this group. A ball of these substances is best made by applyin moist oxide to the end of the platinum wire, and then igniting it in the flame spirit-lamp. The results obtained with these absorbents are, however, generall quite so accurate as those obtained with the sulphate of sodium. The different mem of this group cannot be separated by any eudiometrical process. If several of occur together, the ball of sulphate of sodium used for their absorption must wards be dissolved in water, and the solution analysed in the ordinary way.

Estimation of the Gases of the 2nd Group.—As stated above, the memb this group are all absorbed by caustic potash. A ball of this substance is ma fusing caustic potash and adding sufficient water to render it, when cold, soft enou receive an impression from the nail; the end of the platinum wire bent into a c then placed in a bullet-mould of convenient size, and the fused potash poured in the ball should adhere firmly to the mould when cold, as is sometimes the case, must be applied; it will then easily be removed. On using a potash-ball for abso gases, it must always be moistened with water before introducing it into the When much gas has to be absorbed by this means, the potash-ball should, after hours, be removed from the eudiometer, washed, and then again introduced. It sh be allowed to remain some four to six hours in contact with the gas, in order to e complete absorption.

Hydrosulphuric acid.—This gas is best absorbed by means of a ball of peroxi manganese. The manganese is very finely powdered and made into a thin paste, water; this is introduced into a bullet-mould with the platinum wire in it, and dried on a hot sand-bath. If, however, this ball were at once introduced i gaseous mixture, it would, from its porous nature, absorb an appreciable amou other gases besides hydrosulphuric acid. To obviate this, the ball before being should be thoroughly moistened with a syrupy solution of phosphoric acid; care however be taken that this does not soften the ball, or it may fall to pieces on atte ing to introduce it into the eudiometer. There is also another method of estim this gas, but it is applicable only when sulphurous acid is not present. A potash containing a large quantity of water, but not moistened externally, so that, on drawing it, none of the potash remains in contact with the mercury, is introduced the eudiometer: this absorbs the hydrosulphuric and carbonic acid, if any is pre "Distilled water acidulated with acetic acid, is then boiled in two flasks until a dissolved air has been removed; the contents of one flask is then poured, whilst b into the other, filling it up to the top of the neck. The flask is then well closed

of caoutchouc, so that no bubble of air is left between the
ate. As the liquid cools, the cork is pushed further into
t the formation of a vacuous space and the possible en-
otash, cut off from its platinum wire immediately on with-
ved to dissolve in this liquid when cool, and a few drops
re added." * The amount of hydrosulphuric acid present
s of a standard solution of iodine. In order to free the
or which might arise from impurities in the potash, the
tly in the same way with a ball of the same potash, but
tassium The amount of iodine used in this case is then
used in the former experiment.

as is estimated by exactly the same methods as those
cid.

potash is the reagent always used in determining the
xture. The method of preparing the ball, and the neces-
were described when speaking of potash as the general

s of the 3rd Group.—This group consists of four gases
nate of sodium or by caustic potash. They will be treated
ould have to be separated from a gaseous mixture.

e estimated either directly or indirectly, the method to
r case depending on the quantity present, and the nature
mixed. If other combustible gases are present, or if there
xygen in the mixture, it is always better to estimate
be adopted in determining it indirectly will be described
vas formerly the substance generally used to free a gaseous
ving to the tension of the vapour of the phosphorus acid
oving it, and the action which many gases have in pre-
horus and oxygen at ordinary temperatures, the use of
o incorrect results. A much better method of absorbing
ate of potassium. It may be introduced into the ab-
s of a papier-maché ball, or if liquid reagents are used, a
n of the acid are first introduced and some caustic potash

made by thoroughly macerating some bibulous paper in
ed the platinum wire into a bullet mould, and tied the
it cannot open, as much of the pulp is forced in round the
After being dried on a sand-bath, a hard compact ball is
ly saturated with the pyrogallate of potassium, and then
the gas. The absorption of oxygen by this means is not
often necessary to withdraw the ball from the eudio-
the pyrogallate solution, and introduce it a second time

d oxygen can, of course, never occur together. The best
st to convert it into nitrous acid and then absorb the acid
or this purpose, a few bubbles of oxygen are introduced into
ube, and afterwards potash, either in the solid or liquid
is complete, a further quantity of oxygen is added; if
tion is caused by the potash, then an excess of oxygen is
ain takes place, more oxygen must be added. Having in
t the whole of the nitric oxide is removed, it then only
of oxygen present, by means of pyrogallate of potassium,
this gas is mixed with nitrous oxide, olefiant gas, or hy-
ccording to Dr. Frankland, gives good results; but in the
ons, it is possible that the nitrous acid and peroxide of
oxidising action on them, and thus vitiate the results.
o formerly used as an absorbent for nitric oxide; but it
ry results.

gen, this gas is also estimated sometimes directly, some-
, its direct estimation only will be treated of. This is best
trated solution of **subchloride of copper.** A papier-
e used for the pyrogallate of potassium, is the best means
into the absorption-tube, when the liquid alone cannot be
generally estimated by the indirect method, which yields

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* Bunsen's Gasometry, p. 86.

Olefiant gas.—This gas, together with all others of the formula C^nH^{2n}, is e and rapidly absorbed by means of anhydrous sulphuric acid, dissolved in abo equal weight of the monohydrated acid. This mixture is best introduced into th by saturating a coke bullet with it. The bullet is made by taking a finely powd mixture of equal parts of cannel coal and coke, or anthracite coal, and after i ducing the platinum wire, compressing as much as possible of the mixture int bullet-mould, which is then carefully and slowly heated to redness. By this me hard and compact ball is easily formed. Before introducing it into the acid mix it should always be warmed to expel any moisture present, and after being satu with acid, must be introduced into the gas as quickly as possible. The ball, when drawn after some hours from the eudiometer, should still give off dense white f on coming in contact with air, thus showing that an excess of acid was pre Owing to the tension of the sulphuric acid introduced, and the sulphurous acid is formed, the bulk of gas in the absorption-tube generally increases instead of nishes, on first introducing the coke bullet. To remove the acid vapours thus for after withdrawing the coke bullet, a potash-ball must be introduced.

After the coke bullet has been withdrawn, although at present there is no method known for separating and estimating singly the different hydrocarbons h the general formula C^2H^{2n}, still, if two of them occur together, the amount of eac be easily determined by an indirect method to be described further on.

Gases estimated indirectly.—In estimating the gases belonging to this cla Bunsen's method, the long eudiometer is always used. After having completed th sorptions in the short tube, a portion only of the gas is introduced into the eudion the amount depending on the nature of the gases operated on. In most cas volume occupying about 120 mm. on the scale, will be found convenient. C precautions are, however, necessary in using the tube for exploding gases. In to close securely the open end of the eudiometer, so that no gas may be force at the moment of explosion, a small round piece of cork or wood, of rather greate meter than the eudiometer, is covered on one side with a thick piece of caoutc and the other is so shaped that it rests firmly on the bottom of the mercury-tr Before exploding the gas, the eudiometer is tightly pressed down on to the caoutc and held firmly in this position by a wooden arm pressing on the top of it. In to prevent any air adhering to the surface of the caoutchouc, which, after th plosion, owing to the diminution of pressure, might be sucked up into the eudiom the caoutchouc, before introducing it under the mercury, should always be mois with a solution of corrosive sublimate, which causes the mercury to adhere c to it, and entirely removes the possibility of any air being introduced into the e meter.

It will be found convenient, as it saves much time and calculation, to form fo eudiometer a table of volumes. This is done by introducing a small tube full o and then reading off the height at which the mercury stands; a second tube full is introduced, and the height of the mercury again read off, and so on till the eudio is filled with air. By noting down the level of the mercury in the tube after addition of air, the successive differences of these numbers express the bulk o same amount of gas under different pressures, these pressures depending on the h of mercury in the eudiometer.

The following is part of a table formed in this way:—

Vols.	Height of mercury.	Differences.
1	53	2
2	96	43
3	131	35
4	161	30
5	187	26

The use of this table is to enable the operator to see at a glance the amount o to be added when the mixture is to be exploded; for instance, suppose the heig the mercury in the eudiometer was 131, and the nature of the gas such that 2 vols. of oxygen had to be added, in order that an explosion of the proper degr intensity should take place; by referring to this table the operator would see at that oxygen must be added till the mercury falls to 187. As the object of the is only to show about how much gas has to be added under different circumsta any great degree of accuracy in forming it is not necessary. The readings-off o heights of the mercury, after each addition of air, may be made without the teles and any alteration in the heights of the thermometer and barometer during the o tion need not be taken into account.

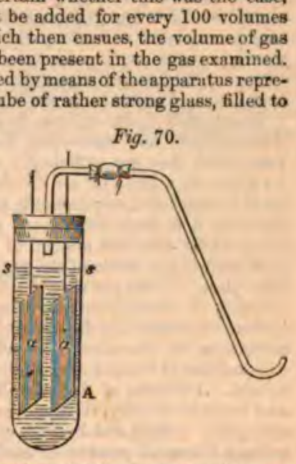
The explosion of the gaseous mixture is best effected by means of an electric s

Leyden jar is charged from an electrophorus or an
the still simpler method adopted by Bunsen, which con-
ge porcelain tube with a piece of silk on which some
rff's coil may also be advantageously used for exploding

r with mercury, a drop of water should always be intro-
hat the volume of gas may be read off saturated with

ts incombustible nature, can, of course, be estimated only
which it is mixed, and measuring the amount remaining;
le to combine with oxygen, so as to remove it entirely
ll known, the oxidation of it does often take place to a
ot properly guarded against, is likely to lead to very
of gases. In fact, the discordant and incorrect results
imenters on the composition of the atmosphere, did no
from this cause. It became then a point of great im-
this oxidation of nitrogen always took place when mix-
oded, and if not, what must be the relative amounts of
e gases present, in order that no trace of any oxide of
We are indebted to Professor Bunsen for a series of ex-
hich remove all uncertainty in the matter. By taking
and electrolytic detonating gas in different proportions,
hen for every 100 volumes of non-combustible gas 26 to
s are taken, no oxidation of the nitrogen takes place.
of nitrogen in a mixture, the following is the process to
ved all absorbable gases and measured off a suitable
ome pure oxygen is introduced, and the volume of gas
spark is now passed through the mixture. Even if no
ensue, it cannot be assumed that the gas was pure
onstituents may have existed in so small a quantity that
osive. In order to ascertain whether this was the case,
tic detonating gas must be added for every 100 volumes
after the explosion which then ensues, the volume of gas
ure nitrogen could have been present in the gas examined.
nentioned may be prepared by means of the apparatus repre-
e A is an ordinary test-tube of rather strong glass, filled to
water freed from air by
few drops of sulphuric
tube is closed with a
very tube, and having
hrough it, to the ends
um plates, serving as
xtremities of the wires
of a voltaic battery of
d the portions of gas
an hour are allowed to
2 vols. hydrogen and
ined, which disappears
at there is no necessity
mixed with any other
be allowed for it to
ixture already in the
alf to three quarters of
elapse, after the introduction of this gas, before the ex-
udiometer should be well agitated.

Fig. 70.



mixture containing this gas with an excess of hydrogen,
very accurately determined, care being taken that the
s a proper relation to the total amount present, so that
nt as to endanger the safety of the tube or oxidise the
not too feeble, as in that case oxygen may escape com-
tal amount of contraction caused by the explosion is the
present. The hydrogen used in these experiments may
from pure zinc and dilute sulphuric acid. To remove
ydrosulphuric acids, and to prevent sulphuric acid being
gas, as it is evolved, should be made to pass through a
h. The evolution of gas should always be allowed to
utes before any of it is passed up into the eudiometer.

For very exact experiments, the hydrogen should be obtained by another process, which yields an absolutely pure gas, namely, from the electrolytic decomposition of water. For the generation of this gas, an apparatus similar in form to that used for obtaining the detonating gas (*fig.* 70), may be used. Instead, however, of two platinum plates, only one is used, and the positive pole consists of a platinum wire melted into the decomposing cell at the bottom, and there brought in contact with a layer of mercury amalgamated with zinc. The acid liquid is of the same degree of strength as in the former apparatus. On now passing the current of a battery through it in the proper direction, pure hydrogen is evolved, and is dried by passing through a small vessel containing sulphuric acid, or a tube containing chloride of calcium.

Hydrogen.—The method of estimating this gas is precisely the reverse of that adopted for the estimation of oxygen. The amount of hydrogen present is represented by $\frac{2}{3}$ of the contraction caused by explosion. The oxygen added is best prepared from powdered chlorate of potassium, contained in small retorts of about the capacity of eight or ten cubic centimetres.

These little retorts are easily made by blowing a bulb at the end of a piece of glass tubing, then introducing the powdered chlorate of potassium, and afterwards bending the tube a little above the bulb, so as to give it the form of a retort. The open end should also be bent upwards, in order that it may be introduced into the eudiometer. The air is, of course, first thoroughly expelled by evolving a considerable amount of gas before any is allowed to enter the eudiometer.

Carbonic Oxide.—The method of estimating this gas by absorption has already been explained; it is, however, most accurately, and in most cases most easily estimated by exploding it with oxygen, and then absorbing the carbonic acid formed by means of potash.

Light Carburetted Hydrogen (Marsh-gas).—This gas is also estimated by exploding it with oxygen, and measuring the contraction which has taken place and the amount of carbonic anhydride formed. This gas and all hydrocarbons containing their carbon and hydrogen, as they do in a condensed form, require much greater dilution with non-combustible gases, in order to modify the violence of the explosion, and prevent the oxidation of any nitrogen which may be present. Pure light carburetted hydrogen should be diluted with from 8 to 12 volumes of air and 2 of oxygen, in order that it may be exploded so as to yield accurate results. The object of using air instead of merely oxygen as the diluent is, that if the gas has afterwards be examined for nitrogen, the amount of oxygen which would be present would probably be so large that the eudiometer could not contain sufficient hydrogen to explode it.

Ethyl, Methyl, &c.—These hydrocarbons are easily estimated by simple combustion with oxygen, and measuring the amount of carbonic acid formed, care only being taken that they are sufficiently diluted with incombustible gas. To pure ethyl some 20 times its volume of air should be added, and 6 or 7 volumes of oxygen. Methyl, on the other hand, requires only about 8 volumes of air and 2 or 3 of oxygen. In operating with a mixture which may contain any of these gases, and of entirely unknown composition, the best method of proceeding is to add at first so much air and oxygen that even if the whole of the gas were ethyl, an explosion of not undue violence would take place. If the gas should not explode on passing the spark through it, then a small quantity of electrolytic gas or hydrogen must be added. In this way all danger of a violent explosion may be avoided. The solubility of the gases in strong alcohol may sometimes be examined with advantage, in order to ascertain roughly what is the composition of the gas operated on, and consequently how much diluent it is necessary to add. 1 volume of alcohol will dissolve some 18 volumes of ethyl, while of methyl and hydride of ethyl it dissolves only about its own volume. With regard to these two gases, methyl and hydride of ethyl, since they are isomeric, and in equal volumes contain the same amount of carbon and hydrogen, they cannot be distinguished by any eudiometrical process.

The methods adopted for calculating the composition of the gas from the data which have been thus obtained, are as follows:—With the gases that are estimated directly the nature of the calculation is easily understood. By taking a definite example, the method used in calculating the amount of combustible gases in a mixture will be rendered very obvious. Suppose then that the gas introduced into the long eudiometer contains hydrogen, carbonic oxide, light carburetted hydrogen, and nitrogen. Oxygen would be introduced, the mixture exploded, and the carbonic acid formed absorbed; then to determine the amount of nitrogen present, hydrogen must be added in excess, and the mixture again exploded to remove the oxygen remaining.

Let a be the amount of gas in the long eudiometer,
b „ „ after the addition of oxygen,
c „ „ after the explosion,

unt of gas after the absorption of the carbonic acid,
„ after the addition of hydrogen,
„ after explosion.
following data are deduced: —

le gas. C, the volume of carbonic acid formed.
nsumed. D, „ nitrogen present.

f oxygen which remained unconsumed by the first ex-
deducted from d, the remainder is evidently the amount

$$D = d - \frac{e-f}{3}$$

ble gas which was present, is found by deducting the
original volume of the gas, thus: —

$$A = a - \left(d - \frac{e-f}{3}\right)$$

of oxygen $\frac{e-f}{3}$ consumed in the second explosion from
we obtain B, the amount consumed by the combustible

$$B = b - a - \frac{e-f}{3}$$

hydride formed, is:

$$C = c - d.$$

being thus known, it will be possible to calculate from
wn quantities:

volume of hydrogen
„ light carburetted hydrogen
„ carbonic oxide

n the hydrogen and carbonic oxide combine with half
eas the marsh-gas requires twice its volume; and further,
marsh-gas on combustion produce a volume of carbonic
olume. These data give, then, the three following equa-

$$\begin{aligned} x + y + z &= A \\ \frac{x}{2} + \frac{z}{2} + 2y &= B \\ y + z &= C \end{aligned}$$

ed the value of x, y, and z —

$$\begin{aligned} x &= A - C \\ y &= \frac{2B - A}{3} \\ z &= C - \frac{2B - A}{3} \end{aligned}$$

ty of these gases present in the mixture. If another
sent, its amount might also have been determined by esti-
by the explosion as well as the carbonic acid; or else
reviously removing the carbonic oxide by subchloride of
described. The aqueous vapour in a gas is estimated by
in a larger tube, and filling the space between the two
hich, as the gas is under a diminished pressure, is quite
e of the water into vapour.
efiant gas series C^nH^{2n} should occur together, the quan-
indirectly estimated in the following way: — A complete
nade in the ordinary manner, absorbing the olefiant gases
and exploding the combustible gases with oxygen. A
rds be made; but, instead of introducing sulphuric acid
ygen is added, and the whole exploded. The difference in
acid formed, and in the contraction which has taken place
tly due to the olefiant gases present.

Let volume of olefiant gases $= A$
" " carbonic acid formed $= B$
" " contraction on combustion $= C$

If the two gases are, for instance, believed to be ordinary olefiant gas and butyl
then, since 1 volume of olefiant gas gives 2 volumes of carbonic acid, and 2 volu
contraction, and 1 volume of butylene gives 4 volumes of carbonic anhydride
3 volumes contraction, then, if x represent the former gas, and y the latter—

$$x + y = A$$
$$2x + 4y = B$$
$$y = \frac{B - 2A}{2}$$
$$x = A - \frac{B - 2A}{2}$$

The contraction C gives also a third formula:

$$2x + 3y = C$$

which, combined with the first equation, gives the values of x and y to be:

$$y = C - 2A$$
$$x = A - C + 2A$$

The values obtained from both these sets of equations ought to agree.

By means of the following table, it will be easy to ascertain what formulæ have to
adopted in calculating the amount of combustible gases present in any mixture.*

Name of Gas.	Volume of Gas.	Volume of Oxygen consumed.	Decrease of volume after explosion.	Vol. o carboni anhydri produce
Hydrogen	1	0·5	1·5	0
Carbonic oxide	1	0·5	0·5	1
Hydride of methyl	1	2·0	2·0	1
Olefiant gas	1	3·0	2·0	2
Methyl	1	3·5	2·5	2
Hydride of ethyl	1	3·5	2·5	2
Propylene	1	4·5	2·5	3
Butylene	1	6·0	3·0	4
Ethyl	1	6·5	3·5	4

If the gaseous mixture consisted, for instance, of hydrogen, carbonic oxide,
nitrogen, and if $A =$ the volume of the gas, C the diminution after explosion, and
the amount of carbonic acid produced, then taking $x =$ hydrogen, $y =$ carbonic a
and $z =$ nitrogen, we have:

$$x + y + z = A$$
$$\frac{3}{2}x + \frac{y}{2} = C$$
$$y = D$$

which gives:

$$x = \frac{2C - D}{3}$$
$$y = D$$
$$z = A - \frac{2C + 2D}{3}$$

As another example may be taken a mixture of hydrogen, carbonic oxide,
hydride of ethyl or methyl gas; then, if x, y, and z represent the quantities of th
gases present:

$$x = \frac{3A + 2C - 4D}{6}$$
$$y = \frac{3A - 2C + D}{3}$$
$$z = \frac{2C + 2D - 3A}{6}$$

---

* The Table is taken from the Handwörterbuch der Chemie.

Bunsen's Gasometry, translated by Roscoe, London, 1857,
Cours élémentaire de chimie, Paris, 2^{me} éd. iv. 73—103;
930—978.) W. J. R.

MICAL. See ANALYSIS, ORGANIC, p. 250.

^{2}.—The fatty matter extracted from grains of paradise or
occulus), is composed of a solid glyceride, called *anamirtin*
h a certain quantity of a free fatty acid. The seeds are
nd colouring matter by digestion in ether, then exhausted
ered ethereal solution is exposed to a low temperature.
arborescent crystals, which are purified by two or three
absolute alcohol. It melts at 35 or 36° C., and on cooling
, but does not crystallise. It is waxy and not friable
xlii. 254.)

ined by saponifying anamirtin with caustic potash and
hydrochloric acid. It then separates as a colourless oil
a white crystalline mass. When dissolved in boiling
on cooling in small needles, which have a nacreous lustre
and solidifies on cooling in very brilliant radiating masses.
. Ch. Pharm. xlii. 254) it contains $C^{35}H^{35}O^4$. Heintz,
ie, pp. 387, and 1671), considers it to be identical with
lt separates from boiling absolute alcohol in elongated
white precipitate, soluble in ammonia, and soon blackened
irtate of ethyl is obtained by passing hydrochloric acid
hot alcoholic solution of anamirtic acid. It separates at
he form of a nearly colourless oil, which solidifies on cool-
le, and is partly decomposed by distillation. It contains
12·69 of oxygen.

SSENCE OF. A solution of butyrate of ethyl in 8 or 10
ssesses the odour of the pine-apple (*Ananassa sativa*), and
and perfumery, also to imitate the flavour of rum. The
must be quite free from volatile fatty acids. (Hofmann

te. Titane anatase. TiO^2.—A pure or nearly pure oxide
tahedrons, belonging to the quadratic or dimetric system,
es, = 136°22 and of lateral edges 97°56. The crystals
d: hence the name, from ἀνάτασις, erection. The mineral
xhibiting various degrees of translucency down to com-
transmitted light is greenish-yellow; by reflected light
hyacinth-red, clove-brown, and iron-black, more rarely
eavage distinct parallel to the octahedral faces. Specific
es after heating, 4·11—4·16. Hardness 5·5—6. It is
acture, and yields a colourless powder. Streak uncoloured.
e. Anatase is found most abundantly at Bourg d'Oisans,
xinite, and ilmenite. It occurs with mica slate in the
of; in the Fichtelgebirg, Norway; and in the Urals; in
th Brookite at Tremadoc, North Wales; in Brazil, in
s detached crystals. It is also said to occur in the slags
range County, New York. (Dana ii. 122; Handw. d.
e BROOKITE, RUTILE, TITANIC ACID.)

TO.

e given by Breithaupt to a hydrated silicate of magnesium
in in Bohemia. Its composition has not yet been ascer-
contains 11·5 per cent. water, and 55·7 per cent. silica.
of a greenish-white colour, with mother-of-pearl lustre,
pecific gravity 2·26. Cleavage in one direction very dis-
(Handw. d. Chem. 2^{te} Aufl. i. 991.)

$H^{16}O^4 = C^9H^{14}O^2.H^2.O^2$. *Lepargylic acid.*—Discovered by
. x. 166) among the products of the oxidation of Chinese
Wirz (Ann. Ch. Pharm. civ. 265) among the products
n the solid fatty acids of cocoa-nut oil.

Chinese wax is heated for several hours with 4 or 5 times
f specific gravity 1·39, the acid which distils over being
reenish distillate is obtained, containing caprylic, œnan-
nd a residue consisting of anchoic acid, together with

suberic and pimelic acids. On boiling this residue with water, evaporating the filt
to the crystallising point, pressing the crystalline crusts thus obtained, washing
ether, and recrystallising from hot water, anchoic acid crystallises out pure, the o
acid remaining in solution. Cerotic acid also yields anchoic acid when treated
nitric acid, but not so readily as Chinese wax (**Buckton**).—2. Several pounds
the solid fatty acids of cocoa-nut oil (obtained by decomposing the soda soap with di
sulphuric acid, and distilling off the volatile acid), are digested with nitric acid
several weeks till the oxidation is complete, and the mass solidifies in a white crys
line magma; this product is dissolved in twice its volume of hot water; and
granular mixture of suberic and anchoic acids which separates is redissolved
recrystallised several times, at last from weak alcohol, till the portion which
crystallises out exhibits the composition of pure anchoic acid. The mother-liq
separated from the crystalline magma of suberic and anchoic acids, contains sev
other acids of the series $C^nH^{2n-2}O^4$ (see ACIDS, p. 52) viz. pimelic, adipic, lipic,
succinic acid. (**Wirz**.)

Properties.—Anchoic acid forms snow-white aggregated nodules (**Buckton**); ro
granules resembling those of suberic acid, but harder (**Wirz**). Melts between 1
and 116° C. (**Buckton**); partially at 115°, completely at 124°, and solidifies on cool
in a finely radiated nacreous mass (**Wirz**). At a stronger heat, it sublimes
partial decomposition, emitting white inodorous vapours, which produce a very s
cating effect when inhaled (**Buckton**): hence the name (*αγχειν*, to suffocate).
dissolves in 217·4 pts. of water at 18° C. and volatilises partially when the solutio
evaporated (**Wirz**). Hot water dissolves it readily, the solution becoming whiter
semi-fluid on cooling (**Buckton**). It dissolves also in alcohol; has an acid taste
reaction.

Anchoic acid is dibasic, the formula of the neutral anchoates being $C^9H^{14}O^4.M$
It also forms acid salts. *Anchoate of ammonium* is an amorphous mass, which disso
readily in water and alcohol, and gives off ammonia when heated. *Neutral anch*
of potassium forms indistinct crystalline masses, which dissolve readily in w
The *acid* salt, $C^9H^{15}KO^4$, forms microscopic granules, which remain unaltered at 140
It dissolves in 3 pts. of cold water, more readily in hot water; soluble also in w
spirit (**Buckton**). The *sodium*-salt crystallises more readily than the potassium-
Neutral anchoate of barium, $C^9H^{14}Ba''O^4$, is obtained by neutralising the acid
baryta-water, or with carbonate of barium, or by precipitating a mixture of
ammonium-salt and chloride of barium with alcohol. Forms a transparent film w
becomes dull at 100° C. (**Buckton**). After drying over sulphuric acid, it form
white opaque mass, having the aspect of porcelain (**Wirz**). It is very solubl
water, insoluble in alcohol and in ether (**Buckton**). It does not appear possibl
prepare an acid anchoate of barium (**Buckton**).

The ammonium-salt forms a gelatinous precipitate with chloride of *calcium*, w
with acetate of *lead*, whitish with *ferrous* sulphate, light brick-red with *ferric* chlo
and bluish-green with *cupric* sulphate (**Wirz**). It also precipitates *zinc*-salts, *m*
rous salts and *mercuric* salts (**Buckton**.) *Anchoate of silver* $C^9H^{14}Ag^2O^4$, obtaine
precipitation from the ammonium-salt, forms a white powder which soon decomp
when moist (**Wirz**): white flocks, which are permanent at 120° C., and dissolve s
ingly in water. (**Buckton**.)

Anchoate of Ethyl. $C^{13}H^{24}O^4 = C^9H^{14}O^4.(C^2H^5)^2$.—Obtained by passing hydrochl
acid gas into the alcoholic solution of the acid. It is a yellowish viscid oil, lig
than water and having an agreeable odour. It boils at 325° C. (**Buckton**). Beco
brown without distilling at 260° (**Wirz**).

ANCHUSIN, or **ANCHUSIC ACID.** The colouring principle of the alk
root (*Anchusa tinctoria*). It is extracted by first macerating the root in
water, to extract the matters soluble in that liquid, then drying it in a stove,
exhausting with alcohol. The solution, at first red, becomes violet by boiling,
of a greyish-green; these changes of colour may, however, be prevented by addin
few drops of hydrochloric acid. The extract is concentrated, and agitated with et
which then becomes charged with the colouring matter, and yields it by evaporatio
the form of a resinous mass. Anchusin is an amorphous substance, having a deep
colour and resinous fracture: the colour is not altered by exposure to light. It sof
at 60° C. At a higher temperature, it gives off very pungent violet vapours, sim
to those of iodine; at a very high temperature, it becomes carbonised. It is insol
in water, but dissolves in alcohol, and especially in ether; oil of turpentine, and f
oils also dissolve it. According to **Bolley** and **Wydler** (Ann. Ch. Pharm. lii.
it contains $C^{35}H^{40}O^8$; 71·33 p. c. C; 7·00 H.

Nitric acid transforms anchusin into oxalic acid and a bitter substance. Con
trated sulphuric acid dissolves it, forming a solution of a beautiful amethyst col

husin blue compounds, soluble in water, less soluble in
ibacetate of lead it forms a bluish-grey precipitate soluble

nchusin evaporated over the water-bath, leaves a blackish
ter extracts a brown substance. The insoluble portion well
en treated with ether, yields a green extract containing,
ydler, $C^{34}H^{44}O^{8}$, and formed from anchusin by fixation of
rbonic anhydride;

$$H^{40}O^{8} + 2H^{2}O = C^{34}H^{44}O^{8} + CO^{2}.$$

$^{3}.SiO^{2}$, or $3Al^{2}O^{3}.2SiO^{3}$.—A crystallised mineral, found
ovince of Andalusia, and occurring also in Scotland, Ireland
calities, in mica-slate, and others of the older rocks. It
ging to the trimetric system, with angles of 91° 35′, and
rom 3·0 to 3·2. Hardness = 7·5. It is infusible before
h difficulty in borax, forming a clear glass, and even less
It is insoluble in acids. The alumina is generally more
ioxide of iron and manganese. The minerals *chiastolite*
composition as andalusite: cyanite, however, belongs to
e prismatic) system, and is found in the oldest plutonic
nd cyanite occur in metamorphic rocks, as in mica-slate
e also found having the external form of andalusite, but
rystalline grains of cyanite. (Handw. d. Chem. 2^te Aufl. i.
ii. 257.)

(*Cera de los Andaquies.*)—The wax of a peculiar species
noco and Amazon rivers, and used as a substitute for
anufacture of candles, &c. According to Lewy (Ann.
has a density of 0·917, melts at 77° C., and contains 81·6
O. It is not, however, a definite compound, but, like
ure of three different fats, one of which, constituting about
insoluble in alcohol, melts at 72° C., and is identical with
btained by boiling the original wax with alcohol deposits
lts at 82° C., and agrees in every respect with *cerosin* ob-
this substance exists in the Andaquies-wax to the amount
alcoholic mother-liquor yields by evaporation about 5 per
further examined.

l resembling felspar in external appearance, but differing
osition. It may be represented by the general formula

+ $Al^{2}O^{3}.3SiO^{2}$, or (regarding silicic acid as tribasic) =

O^{3}), the symbol M denoting potassium, sodium, calcium,
ls may replace each other in any proportions. Specific
l was originally obtained from the Andes, but has since
d in other localities. (Handw. d. Chem. 2^te Aufl. i. 993.)

TE and **ANDREOLITE**. See HARMOTOME.

O^{6} (?)—A crystalline body, obtained from the leaves of
viz. *Anemone pulsatilla*, *A. pratensis*, and *A. nemorosa*.
es deposits, after some weeks, a white inodorous substance,
giving off water and acrid vapours. It is purified by
om boiling alcohol.
he trimetric system. In the cold, they are but sparingly
nd water dissolve but little, even at a boiling heat; the
monin is a poisonous substance; applied to the skin, it

nemonin is transformed into anemonic acid. Boiled with
yields a crystalline compound, $C^{30}H^{12}O^{11}.PbO$, soluble in
huric acid blackens anemonin. Hydrochloric acid dissolves
. By oxidising agents, such as peroxide of manganese and
ted into formic acid. Chlorine attacks it readily when
ic acid and an oily volatile body.

s name has been applied to an acid substance produced by
on anemonin (Löwig and Weidmann, Pogg. Ann. xlvi.
orphous substance, which is deposited together with ane-
mone water (Schwarz, Mag. Pharm. x. 193; xix. 168;

Fehling, Ann. Ch. Pharm. xxxviii. 218). Both these substances are said to con
of anemonin together with the elements of water. (Gerhardt, Traité iv. 263.)

ANGELICA BALSAM. When the root of archangel (*Angelica archangel*
is exhausted with strong alcohol, and the residue left after distilling off the grea
part of the alcohol is evaporated over the water-bath, a viscid mass is obtained, whi
when washed with water and digested in ether, yields a solution from which, by e
poration, a black-brown balsam is obtained, amounting to about 6 per cent. of the r
This balsam is a mixed product, and on treating it with potash-ley and distilling
part of the water, a small quantity of an essential oil (*angelica-oil*) separates; on c
tinuing to heat the mass with the alkaline liquid, a waxy body (*angelica-wax*), is
behind: and the liquid concentrated to a certain point yields a crystalline re
angelicin. On distilling the residue with excess of sulphuric acid, butyric acid pas
over with the water, and afterwards angelic acid. (Buchner, Ann. Ch. Pharm. x
226.)

ANGELIC ACID. $C^5H^8O^2 = \left.\begin{matrix}C^5H^7O\\H\end{matrix}\right\}O$, [or $C^{10}H^7O^3.HO$.]—This acid ex
in the root of the archangel, *Angelica archangelica* (Buchner, Ann. Ch. Pharm. x
226), and in sumbul, or moschus root, a drug imported from Asia Minor, and proba
also belonging to an umbelliferous plant. From *archangel root* it is prepared by b
ing fifty pounds of the root, cut into small pieces, with four pounds of lime and w
water, straining through a cloth, concentrating the liquid, and distilling it with dil
sulphuric acid. A complex distillate is then obtained, which is neutralised with pota
and evaporated to dryness over the water-bath. The residue, distilled with sulphu
acid diluted with twice its weight of water, yields first a distillate of water, acetic a
and valerianic acid, and afterwards angelic acid, part of which crystallises in the n
of the retort, while the rest passes into the receiver; on leaving the distilled liquid
a cold place for some days, the angelic acid dissolved in it crystallises out. T
crystals are washed with a small quantity of water, and repeatedly crystallised to f
them from valerianic acid (Meyer and Zenner, Ann. Ch. Pharm. lv. 307).—Fr
sumbul root the acid is obtained by exhausting the root with alcohol, evaporating
filtered solution, boiling the residual balsam with strong potash-solution, filtering
separate a volatile oil, mixing the brown-red alkaline filtrate with sulphuric a
which separates a dark brown oil, and distilling this oil with water, added at interv
as long as the distillate continues to be mixed with drops of oil. This distillate,
aside in a cold place, deposits angelic acid, which may be purified by twice saturat
it with carbonate of sodium, distilling with sulphuric acid, then distilling it alone,
lastly, boiling it for a long time to separate sumbulamic acid. (Reinsch, Jahrb.
Pharm. vii. 79.)

Angelic acid is also produced by heating the essential oil of chamomile (*Anthe*
nobilis)—which consists of angelic aldehyde, together with a hydrocarbon (C^5H
with hydrate of potassium:

$$\underset{\text{Angelic aldehyde.}}{C^5H^8O} + KHO = \underset{\text{Angelate of potassium.}}{C^5H^7KO^2} + 2H$$

The oil must be gently heated with pulverised and tolerably dry potash, till
temperature of the mass rises considerably, and hydrogen begins to escape. If
source of heat be then removed, the action goes on by itself, the hydrocarbon v
tilises, and angelate of potassium remains mixed with the excess of hydrate.
dissolving this residue in water, taking off the small remaining portion of oily hyd
carbon with a pipette, and treating the solution with sulphuric acid, angelic acid r
to the surface in the form of an oil, which solidifies in a crystalline mass on cool
This mode of preparation is much more productive than the preceding, provided
application of heat be discontinued at the right time. If it be continued too long, w
the view of expelling the whole of the hydrocarbon not attacked by the potash, a c
siderable portion of the angelic acid will be resolved into acetic and propionic acid

$$C^5H^8O^2 + 2H^2O = C^2H^4O^2 + C^3H^6O^2 + H^2,$$

the admixture of which greatly impedes the crystallisation of the angelic a
(Gerhardt, Traité ii. 449.)

Angelic acid is also produced, together with oreoselin, by treating peucedanin w
alcoholic potash:

$$\underset{\text{Peucedanin.}}{C^{12}H^{12}O^3} + KHO = \underset{\text{Angelate of potassium.}}{C^5H^7KO^2} + \underset{\text{Oreoselin.}}{C^7H^6O^2}$$

(Wagner, J. pr. Chem. lxii. 275.)

Angelic acid crystallises in large long prisms and needles, which are colourless

°C., boils at 190°, and distils without decomposition. It r, a sour but aromatic taste, and reddens litmus. It burns oky flame. It dissolves sparingly in cold, but abundantly ystallises in needles on cooling. In alcohol, ether, oil of ssolves with great facility.

and belongs to the series of acids whose general formula

nown members of which are acrylic acid (C^3), pyroterebic

ic (C^{18}).

li-metals are soluble in water and alcohol. The *calcium*-forms shining laminæ, very soluble in water. The soluble ts, a white precipitate, $(C^5H^7O^2)^2Pb''$, soluble in a large *ic* salts, a flesh-coloured insoluble precipitate; with *cupric* gly soluble precipitate; with *mercurous* nitrate, a white s grey and redissolves; with *mercuric* chloride, no pre-of *silver*, a white precipitate, which dissolves in a large solution which after a while deposits metallic silver.—A oxide of silver in the boiling aqueous acid, yields, when possible heat, small greyish-white crystals of the normal imes also laminæ of a basic salt. (Meyer and Zenner.) *Ether*, is obtained by distilling angelate of sodium with ulphuric acid, and 2 pts. of 94 per cent. alcohol. It is a smells like sour apples, has a sweetish, burning, aromatic and headache when inhaled. (Reinsch and Recker,

, or *Anhydrous Angelic Acid*, $C^{10}H^{14}O^3 = (C^5H^7O)^2O$.--- xychloride of phosphorus on angelate of potassium:

$$\underset{\substack{\text{xychloride}\\ \text{phosphorus.}}}{PO.Cl^3} = \underset{\substack{\text{3 at. angelic}\\ \text{anhydride.}}}{\left.\begin{matrix}(C^5H^7O)^3\\ (C^5H^7O)^3\end{matrix}\right\}O^3} + PO^4K^3 + 3KCl$$

the action yields, when treated with carbonate of sodium tion which leaves the anhydride on evaporation. It is a , heavier than water, and having a peculiar odour quite acid. It does not crystallise, even at the temperature of When distilled, it begins to boil at 240° C., but the boiling-nd the compound is subsequently decomposed, yielding a d a neutral oil, and leaving a carbonaceous residue.—The lered acid by the action of water, but dissolves readily in queous ammonia first converts it into a buttery mass, and ct with aniline, it becomes strongly heated, and deposits , $N.H,C^6H^5,C^5H^7O$. (Chiozza, Ann. Ch. Phys. [3] xxxix.

talline substance obtained, according to Buchner, by treat-tash (p. 287).

iety of vivianite, found at Arglac, in the department of the

Sulphate of Lead.

n organic base, said by Brande to exist in true angustura Its existence is doubtful.

ondary Negative Oxides, or *Oxides of Acid-radicles*.—These *anhydrous acids*, and are sometimes even confounded with position, they stand in the same relation to acids as oxide n, KHO; or, generally, as anhydrous (secondary) oxides, s): that is, they represent one or more atoms of water, as the standard of comparison for all oxides), in which is replaced by one or more negative radicles; while the nt one or more atoms of water in which the same radicles ogen.

= $Cl.Cl.O$, hypochlorous acid = $H.Cl.O$,
= $NO^2.NO^2.O$, nitric „ = $H.NO^2.O$,
= $C^2H^3O.C^2H^3O.O$, acetic „ = $H.C^2H^3O.O$,
= $C^7H^5O.C^7H^5O.O$, benzoic „ = $H.C^7H^5O.O$,

Aceto-benzoic anhydride $= \mathrm{C^2H^3O.C^7H^5O.O}$,
Sulphuric „ $= \mathrm{SO^2.O}$, sulphuric acid $= \mathrm{H^2.SO^2.O^2}$,
Succinic „ $= \mathrm{C^4H^4O^2.O}$, succinic „ $= \mathrm{H^2.C^4H^4O^2}$.
Phosphoric „ $= \mathrm{PO.PO.O^3}$, phosphoric „ $= \mathrm{H^3.PO.O^3}$.

From these instances it is evident that there are three classes of anhydrides, nan
(*a*) those which derive from 1 at. water by the replacement of $\mathrm{H^2}$ by 2 atoms o
same monatomic acid-radicle (hypochlorous, acetic, &c.), or by 2 different monat
radicles (aceto-benzoic, &c.); (*b*) those which derive from 1 at. water by the rep
ment of $\mathrm{H^2}$ by 1 atom of a diatomic acid-radicle (sulphuric, &c.); (*c*) those w
derive from 3 at. water by the replacement of $\mathrm{H^6}$ by 2 atoms of a triatomic acid-ra
(phosphoric). Anhydrides deriving from 2 at. water have not yet been show
exist.

All anhydrides are more or less quickly converted into acids by the action of w
or of hydrates; in the dry state, or when dissolved in ether or other liquids whic
not change them into acids, they are without action on litmus or other vege
colours.

Anhydrides (*a*) are obtained by the action of chlorides of monatomic acid-radicl
monatomic acids or salts:

$$2(\mathrm{Cl.Cl}) + \underset{\substack{\text{Hypochlorite}\\ \text{of mercury.}}}{\mathrm{Hg''.Cl^2.O^2}} = \mathrm{Hg''.Cl^2} + \underset{\substack{\text{Hypochlorous}\\ \text{anhydride.}}}{2(\mathrm{Cl.Cl.O.})}$$

$$\underset{\substack{\text{Chloride of}\\ \text{benzoyl.}}}{\mathrm{C^7H^5O.Cl}} + \underset{\substack{\text{Acetate of}\\ \text{potassium.}}}{\mathrm{K.C^2H^3O.O}} = \mathrm{KCl} + \underset{\substack{\text{Aceto-benzoic}\\ \text{anhydride}}}{\mathrm{C^2H^3O.C^7H^5O.O.}}$$

They are liquid, or solid bodies, and those which contain only one acid-radicle
usually volatile without decomposition: those which contain two acid-radicles
decomposed by heat into two anhydrides, each containing one radicle.

$$\underset{\substack{\text{Aceto-benzoic}\\ \text{anhydride.}}}{\mathrm{C^2H^3O.C^7H^5O.O}} + \underset{\substack{\text{Aceto-benzoic}\\ \text{anhydride.}}}{\mathrm{C^2H^3O.C^7H^5O.O}} = \underset{\text{Acetic anhydride.}}{\mathrm{C^2H^3O.C^2H^3O.O}} + \underset{\text{Benzoic anhydride.}}{\mathrm{C^7H^5O.C^7H^5O.O.}}$$

The anhydrides of this class, which correspond to organic acids, are insoluble or
slightly soluble in water; they dissolve in alcohol, but are gradually decomposed b
forming salts of ethyl (compound ethers); in ether they dissolve without alteratio

Ammonia and its derivatives convert them into amides, or alkalamides.

$$\underset{\text{Benzoic anhydride.}}{\mathrm{C^7H^5O.C^7H^5O.O}} + 2\mathrm{NH^3} = \mathrm{H^2O} + \underset{\text{2 at. benzamide.}}{2(\mathrm{N.C^7H^5O.H^2})}$$

$$\underset{\text{Acetic anhydride.}}{\mathrm{C^2H^3O.C^2H^3O.O}} + \underset{\substack{\text{2 at. phenyl-}\\ \text{amine (aniline).}}}{2\mathrm{N.C^6H^5.H^2}} = \mathrm{H^2O} + \underset{\text{2 at. phenylacetamide.}}{2(\mathrm{N.C^2H^3O.C^6H^5.H})}$$

With perchloride of phosphorus they give chlorides of monatomic acid-radicles:
sulphide of phosphorus, sulphanhydrides (secondary negative sulphides).

The anhydrides (*b*) correspond to dibasic or diatomic acids. They are forme
the decomposition of these acids, or their salts, by heat.

$$\underset{\text{Succinic acid.}}{\mathrm{H^2.C^4H^4O^2.O^2}} = \mathrm{H^2O} + \underset{\substack{\text{Succinic}\\ \text{anhydride.}}}{\mathrm{C^4H^4O^2.O}}$$

$$\underset{\substack{\text{Sesquisulphate}\\ \text{of iron.}}}{\mathrm{Fe^2.(SO^2)^3.O^6}} = \underset{\substack{\text{Sesqui-}\\ \text{oxide of}\\ \text{iron.}}}{\mathrm{Fe^2O^3}} + \underset{\substack{\text{3 at. sul-}\\ \text{phuric an-}\\ \text{hydride.}}}{3(\mathrm{SO^2.O})}$$

With ammonia, they give ammonium-salts of amic acids:

$$\underset{\substack{\text{Succinic}\\ \text{anhydride.}}}{\mathrm{C^4H^4O^2.O}} + 2\mathrm{NH^3} = \underset{\substack{\text{Succinamate of ammo-}\\ \text{nium.}}}{\mathrm{N.C^4H^4O^2.H^2NH^4.O}}$$

and, to some extent, also secondary amides (imides):

$$\underset{\substack{\text{Succinic anhy-}\\ \text{dride.}}}{\mathrm{C^4H^4O^2.O}} + \mathrm{NH^3} = \mathrm{H^2O} + \underset{\text{Succinimide.}}{\mathrm{N.C^4H^4O^2.H}}$$

They react in a similar way with phenylamine (aniline) and some other primary d
vatives of ammonia.

Perchloride of phosphorus converts them into chlorides of diatomic acid-radicles

In the case of sulphuric anhydride, $\mathrm{SO^3}$, or $\mathrm{SO^2.O}$, which has been much m
minutely studied than any other anhydride of this class, certain additional react

nstance, it has been found to combine with hydrochloric
phuric acid:

$$SO^3 + HCl = HSO^3Cl$$

Chlorhydro-sulphuric acid.

orides, inorganic and organic (chlorides of ammonium,
to form compounds which represent the metallic salts and
combines with hydrocarbons, producing neutral compounds

$$+ \quad C^2H^4 = C^2H^4S^2O^6$$

Ethylene. Ethionic anhydride.

$$+ \quad 2C^6H^6 = H^2O + C^{12}H^{10}SO^2$$

2 at. benzine. Sulphobenzide.

reactions with those produced by acids in similar circum-
kes it clearly evident that anhydrides and acids are essen-
nical characters.

rides (*c*) are yet known. Phosphoric anhydride, P^2O^5, or
known member of this class. It is obtained by the direct
and oxygen. Ammonia converts it into phosphamic acid:

$$O^5 + 2NH^3 = H^2O + 2(NH.PO.HO)$$

orus it gives oxychloride of phosphorus (chloride of phos-
anhydride, it combines with hydrochloric acid.—G. C. F.

drous sulphate of calcium. There are six varieties of it:
hades of white, blue, and red; massive and kidney-shaped;
nchoïdal fracture; translucent on the edges; is scratched
par; somewhat tough: specific gravity 2·850. It contains
ound in the salt mines of Austria and Salzburg, and at the
; also in the gypsum pits at Ashton-on-Trent, near Derby
of Jameson, is found in massive concretions, of which the
ed. White or bluish colour, with a pearly lustre. Compo-
cent. of sea-salt. It occurs in the salt mines of Halle.
Fibrous. Massive; glimmering, pearly lustre; fracture in
rcely translucent; easily broken. Found at Halle, Ischel,
adiated. Blue, sometimes spotted with red; radiated, splen-
y; translucent; not hard; specific gravity 2·940.—5. *Sparry*
colour, passing sometimes into greyish and reddish-white;
onging to the trimetric system, having two of the opposite
e other two; occasionally the lateral edges are truncated,
ed prism belonging to the trimetric system; lustre splendent,
hreefold rectangular cleavage; cubical fragments; translu-
brittle; specific gravity 2·9. This is the *muriacite* of some
cting. It is said to contain 1 per cent. of sea-salt. It is
nd, and Halle in the Tyrol.—6. *Siliciferous*, or *Vulpinite*.
aminated structure; translucent on the edges; splendent
veined with bluish-grey; specific gravity 2·88. It con-
e rest is sulphate of calcium. It is called by statuaries,
mo, and takes a fine polish. It derives its name from
ccompanies lime. U.

lete synonyme of indigo. The same term is also used as
s (*q. v.*)

Syn. of Phenylamic Acid.

Phenylamides.

henylamine.

The process or series of processes by which food is con-
of the animal body (see Digestion and Nutrition). The
rts to denote the operation by which vegetable fibres, such
e to unite with albuminous substances.

properly called *gum-animé*.—A resinous substance used for
ee varieties of it, the East Indian, the West Indian, and the

brown American. West Indian animé, sometimes called *courbaril resin*, is the dnce of the *Hymenæa Courbaril*, a tree belonging to the order *Cæsalpiniæ*, growi the West Indies and in South America; the other varieties are of unknown or The West Indian resin forms yellowish-white transparent, somewhat unctuous t or sometimes larger masses; it is brittle; of a light pleasant taste, and very agre odour; hence its use in fumigation and in perfumery. It softens in the mouth, easily in the fire, and burns with a bright flame. Specific gravity 1·028 (Bresa 1·032 (Paoli). Insoluble in water, perfectly soluble in hot alcohol. Cold al dissolves about 54 per cent. of it. The soluble portion is, according to Lau identical with the resin of turpentine. The insoluble portion crystallises boiling alcohol in slender colourless needles, consisting, according to Lauren 83·6 per cent. C, 11·5 H, and 4·9 O, agreeing with the formula $C^{20}H^{32}O$. Accor to Filhol, the resin of *Hymenæa Courbaril* is nearly insoluble in cold absolute alc melts at 100° C, and contains 85·3 per cent. carbon, 11·5 hydrogen, and 3·2 oxyg

Brown American animé softens in the mouth, and dissolves completely in alcohol; specific gravity 1·0781 (Paoli). Oriental animé, which, according to boust, is no longer met with in commerce, is likewise perfectly soluble in cold alc has a density of 1·027, and appears to consist of two resins, differing in me point (Paoli, Trommsdorff's Journ. Bd. ix. St. 1; s. 40, 61; Guiboust, Rev. Sc xvi. 177; Laurent, Ann. Ch. Phys. [2] lxvi. 315; Gerhardt, Traité, iii. Filhol, J. Pharm. [3] i. 301, 507.)

There is some confusion respecting the use of the word *animé*, the French design copal as *résine animé;* and denoting the West Indian animé or courbaril resin, by term *Copal* or *animé tendre*.

ANIMINE. An organic base obtained, together with three others, *odo* *ammoline*, and *olanine*, from bone-oil (*Oleum animale Dippelii*), by Unverdorbe 1826 (Pogg. Ann. xi. 59 and 67). None of these bases were prepared by Unverdo in a state of purity. Odorine was afterwards obtained pure, and more exactly in tigated under the name of *picoline*, by Anderson, who showed that it is isomeric aniline, C^6H^7N. The other three bases, which were less volatile than odorine, probably mixtures of the homologous bases *lutidine*, C^7H^9N, and *collidine*, C together with other substances. (See Gm. xi. 273.)

ANION (from ἄνιον, that which goes up).—A term used by Faraday to denote element of an electrolyte, which is eliminated at the positive pole or *anode;* the o element, which is eliminated at the negative pole or *kathode*, being called a *k* (κάτιον, that which goes down). To understand these terms, we must suppose decomposing body to be so placed that the current (of positive electricity) pa through it, shall be parallel to, and in the same direction with, that which is supp to exist in the earth, viz. from east to west, or in the direction of the sun's diu motion. The positive pole or electrode will then be towards the east. (Farad Experimental Researches in Electricity, vol i. p. 196.)

ANISAMIC ACID. $C^8H^9NO^3$. (Zinin, Ann. Ch. Pharm. xcii. 327.)— tained by passing hydrosulphuric acid into a mixture of nitranisic acid with 8 of alcoholic ammonia. After twelve hours, when the acid is dissolved, the who boiled, with occasional addition of water, till all the alcohol is driven off; it is filtered from the separated sulphur, and mixed with acetic acid, which precipit anisamic acid in long brown needles: they are obtained colourless by solution in w and treatment with animal charcoal. It forms thin, brilliant, four-sided prisms, w dissolve but slightly even in boiling water, or in ether, but are readily soluble in alc Hydrochloric and boiling acetic acid dissolve it unchanged; its solution in dilute n acid reddens on long boiling, and by cooling deposits brown flakes and a white pulv lent substance. It melts at 180°C., and is decomposed at a higher temperature.—The anisamate that has been analysed is the *silver-salt*, $C^8H^8AgNO^3$: it is a curdy precipit insoluble in water, readily soluble in ammonia and acids; in the dry state, it ma heated to 120° C. without decomposition, but turns brown when boiled with w The *ammonium-salt* is very soluble, and crystallises with difficulty in four-s tables; its aqueous solution is partially decomposed by boiling, ammonia being evol and the acid crystallising out on cooling. The *lead* and *cadmium-salts* are w precipitates. An aqueous solution of anisamic acid does not precipitate lime baryta-water, or silver-salts. With ammoniacal sulphate of copper, it gives, in cold, a light blue flocculent precipitate, which, on boiling, becomes pulverulent, an a cinnamon colour.

The mode of formation of anisamic from anisic acid being analogous to that of benzamic acid from benzoic acid, it should perhaps be regarded as *oxyanisamic*

$$\left.\begin{matrix}H^2\\(C^8H^5O)'''\\H^2\end{matrix}\right\}\begin{matrix}N\\O^2\end{matrix}$$

F. T. C.

[or, rather, *anisamic acid*, $\left.\begin{matrix}H^2\\(C^8H^6O)''\\H\end{matrix}\right\}\left\{\begin{matrix}N\\O\end{matrix}\right.$]. (Cahours,
)—Obtained by treating chloride of anisyl with dry am-
lved, and the mixture becomes a solid mass of anisamide,
whence it crystallises by spontaneous evaporation in
ned by the action of ammonia on anisate of ethyl in a

F. T. C.

izzaro, Compt. rend. l. 1100).—These bases are pro-
alcoholic ammonia on the chlorhydrin of anisic alcohol

$$^9OCl + NH^3 = \underset{\text{Anisamine.}}{C^8H^{11}ON} + HCl.$$

$$^9OCl + NH^3 = \underset{\text{Dianisamine.}}{C^{16}H^{19}O^2N} + 2HCl.$$

from sal-ammoniac by digestion in water, then dissolved
tained by evaporating the alcoholic solution to dryness,
ether, of a mixture of the hydrochlorates of the two
are separated by water, the anisamine-salt being much
and the bases are obtained in the free state by adding
ations of the hydrochlorates, then agitating with ether,
solution.

mall needles, soluble in water, alcohol, and ether, and
bove 100° C. *Dianisamine* forms at first a thick oil,
allises in white laminæ. It is soluble in alcohol and in
than anisamine. It melts and solidifies between 32°

strong bases. The *chloroplatinate of anisamine*,
allises in small gold-yellow laminæ. The *chloroplatinate*
$HCl).PtCl^4 + H^2O$, is precipitated as a brown oily liquid,
of yellow needles.

bases may be viewed in two different ways. If anisic
omic $= C^8H^9O.H.O$, the bases then appear as ordinary
C^8H^9O, viz.:

$$N\left\{\begin{matrix}H^2\\C^8H^9O\end{matrix}\right.;\ \text{Dianisamine} = N\left\{\begin{matrix}H\\(C^8H^9O)^2\end{matrix}\right.$$

hol to be diatomic $=(C^8H^8)''.H^2.O^2$, then the bases must
p. 197), viz.:

$$\begin{matrix}N\\O\end{matrix}\left\{\begin{matrix}(C^8H^8)''\\H^3\end{matrix}\right.;\ \text{Dianisamine} = \begin{matrix}N\\O^2\end{matrix}\left\{\begin{matrix}(C^8\overset{''}{H}{}^8)^2\\H^3\end{matrix}\right.$$

PHENYLANISAMIDE, under PHENYLAMINE.

ence d'anis. Anisöl.—The name given to the essential
llation with water from the seeds of the common anise
China or star anise (*Illicium anisatum*). (According to
½ oz. oil.) This oil contains an oxygenated principle,
lising agents, is converted into hydride of anisyl. The
ne oils extracted from fennel (*Anethum fœniculum*), and
culus). All these oils may, therefore, be conveniently
, though they differ slightly in their physical properties.
nnel is a neutral, yellowish, somewhat syrupy liquid,
c smell and taste. Its specific gravity varies from 0·977
proportions in cold alcohol of specific gravity 0·806, and in
ity 0·84 at 25° C. It appears to consist of two distinct oils,
nperatures below 10°, while the other remains fluid at all
hing is known of the latter of these oils; according to
et seq.) it is isomeric with oil of turpentine. The former,
anethol or *anise-camphor*, has been examined by
[3] iii. 274). The proportion of these two constituents
f the commercial oil; but generally the camphor composes
il absorbs oxygen when exposed to the air, becomes more
property of solidifying by cold. In order to obtain the
ty, it is freed from the liquid oil by pressure between
epeatedly crystallised from alcohol of specific gravity 0·85.
lustrous laminæ, of specific gravity 1·014, having a smell
more agreeable than, that of the crude oil. It is very

friable, especially at 0° C.; melts at 18° C., and at 222° boils and volatilises
pletely, but not without slight coloration. Its formula is $C^{10}H^{12}O$. Its vapour-de
taken at 338° C., is 5·19; at lower temperatures, its density is higher. It is not aff
by exposure to the air in the solid state; but, if kept in a state of fusion, it grad
ceases to solidify on cooling, and finally resinifies completely. *Nitric acid* con
it into hydride of anisyl, anisic or nitranisic acid, and oxalic acid; the products
with the concentration of the acid. Generally a yellow resinous substance is also fo
to which Cahcurs gives the name ***nitranisside***, and the formula $C^{10}H^{10}(NO^2)$
This is a very insoluble substance, which melts at about 100° C., and is completel
composed by distillation; when treated with a strong solution of potash, it giv
ammonia abundantly, and is converted into a black substance, which Cahours
melanisic acid. Under certain circumstances, the action of dilute nitric acid pro
an acid containing 10 atoms carbon (see ANISOIC ACID). When distilled with *sulp*
acid and *bichromate of potassium*, oil of anise yields anisic and acetic acids. (Hen
Ann. Ch. Pharm. lix. 104.)

Strong boiling solutions of *caustic alkalis* do not attack oil of anise; but when
heated with potash-lime in a sealed tube to the boiling point of the oil, a pe
acid is formed, which appears to be isomeric with cuminic acid. (Gerhardt.)

Anise-camphor treated with *acid sulphite of sodium*, is resolved into methyl
hydride of anisyl, $C^{10}H^{12}O + H^2O = 2CH^3 + C^8H^8O^2$. (Städeler and Wäc
Ann. Ch. Pharm. cxvi. 172.)

Anise-camphor absorbs *hydrochloric acid* gas abundantly, forming a liquid
pound, $C^{10}H^{12}O.HCl$, which contains 19·8 per cent. chlorine. It absorbs *ch*
rapidly, with evolution of heat and vapours of hydrochloric acid, forming substitu
products, in which the number of atoms of hydrogen replaced by chlorine varies
the duration of the action of the gas. The trichlorinated compound (***chloran***
$C^{10}H^9Cl^3O$, is a syrupy liquid, which is completely decomposed by distillation,
from which, by the further action of chlorine, aided by heat, a still higher chl
compound may be obtained. Oil of anise treated with *pentachloride of phosph*
yields a liquid boiling at a high temperature, probably $C^{10}H^{12}Cl^2$. (Aelsmann
Kraut, J. pr. Chem. lxxvii. 490.)

When anhydrous *bromine* is gradually added to anise-camphor, heat and h
bromic acid are evolved, and the whole becomes liquid, and finally, when the bro
is in excess, solidifies after a time; it is then washed with cold ether, and re
tallised from boiling ether. The ***bromanisal***, $C^{10}H^9Br^3O$, thus obtained forms
lustrous crystals, insoluble in water, very slightly soluble in alcohol; it is decompos
heat, decomposition commencing at about 100° C.: it is not further acted on by bro

When oil of anise is treated with *perchloride of tin* or *trichloride of antin*
it thickens into a red pitchy mass, which, when boiled with water, deposits a
substance, apparently isomeric with anise-camphor. Cahours calls it ***anisoin***
is also formed when oil of anise is gradually mixed with 1½ pts. strong sulp
acid, and the resulting resinous mass treated with water. It is purified by soluti
ether, and reprecipitation by dilute alcohol. Thus obtained, it is a white, inod
solid which fuses a little above 100° C., and, when further heated, burns with a bri
flame and an aromatic smell; it is heavier than water; insoluble in water, a
insoluble in alcohol, even on heating; more soluble in ether and volatile oils.
soluble in strong sulphuric acid, forming a red solution, whence it is reprecipitate
water. It is not attacked by a boiling solution of caustic potash. When distill
partly volatilises unchanged and partly passes over as an isomeric oil. When
stallised from its ethereal solution, it forms very small white needles. The subs
obtained by Will (Ann. Ch. Pharm. lxv. 230), by dropping oil of anise into a s
solution of *iodide of potassium saturated with iodine*, and treating the resulting m
with 6 or 8 times its volume of alcohol, is, according to Gerhardt, whose state
is confirmed by the recent experiments of Aelsmann and Kraut (*loc. cit.*), ide
with anisoin. This substance, when treated with chlorine, yields a chlorine su
tution-compound.—Anisoin is also produced by treating oil of anise with chlor
benzoyl. (Aelsmann and Kraut.)

When anise-camphor is distilled with *chloride of zinc*, a volatile oil passes
which after a time generally deposits crystals, volatile without decompositio
not melting at 100° C. Both oil and crystals have the same composition a
original camphor; and the vapour-density of the oil is the same as that o
camphor. The oil is readily soluble in strong sulphuric acid, forming a fine cr
solution; the addition of water destroys the colour, but does not precipitate anyt
By saturating the aqueous solution with carbonate of barium, a gummy salt i
tained, whose solution gives a dark violet colour with ferric salts; both acids
alkalis destroy the colour (Gerhardt). The same product is obtained when
anise or anise-camphor is treated with 3—4 pts. concentrated sulphuric acid,

es filtered off, and the aqueous filtrate saturated with
s to be identical with Laurent's *sulphodraconate of*
oil of tarragon.

ent, Revue Scient. x. 6) consists mainly of a camphor
nd behaving in the same manner with nitric and sul-
lorides. The proportion of liquid oil in this essence
e oil does not boil below about 200° C., and the boiling
, where it remains stationary. Its specific gravity is
t 230°. When treated with chlorine, it evolves heat and,
ecomes more syrupy; one of the products thus obtained
ut the consistence of turpentine, gave on analysis per-
cate the formula $C^{10}H^{10}Cl^2O.Cl^2$. When treated with
ce yielded a thick oil (*chlorodraconyl*) containing 42·5
ent. hydrogen.

hours, *loc. cit*).—This essence is composed of two oils,
readily be obtained pure by fractional distillation. Its
t of anise-camphor; but it does not solidify at 10° C. Its
ess than that of water; it boils at 225° C. Treated with
ise-camphor; with bromine it gives a liquid viscous pro-
purify. The more volatile oil appears to have the same
e. It boils about 190° C. When a stream of nitric oxide is
d turbid, and on addition of alcohol of specific gravity 0·80,
e, which is purified by repeated washing with alcohol. This
ystalline needles, contains $3C^{10}H^{16},8NO$. It is discoloured
a higher temperature is entirely decomposed. It is scarcely
gravity 0·80, rather more in absolute alcohol, still more
ustic potash, and reprecipitated by acids. When heated
nmonia, an oil smelling like petroleum, and a gas which
ted with sulphydrate of ammonium in the cold, and then
itate which explodes slightly when heated; the filtrate
ipitate with ferric salts. It dissolves in boiling sulp-
ing a brown solution, and depositing sulphur, while a
lmonds is evolved. It is scarcely attacked by boiling
iozza.) F. T. C.

Hydrure d'azoanisyl. $C^{24}H^{24}N^2O^3$. (Cahours, Ann. Ch.
ion of ammonia upon hydride of anisyl is analogous to
e hydrides of benzoyl and salicyl, a hydramide being

$$ + 2NH^3 = \underset{\text{Anishydramide.}}{C^{24}H^{24}N^2O^3} + 3H^2O$$
of

y abandoning for some time a mixture of 1 vol. hydride
a saturated aqueous solution of ammonia, in a closed
ls of anishydramide gradually form, until, after some
semi-solid mass. The crystals are then freed from ad-
ween folds of filtering paper, and dried. They are hard,
sily powdered; insoluble in water, soluble in boiling
rm concentrated hydrochloric acid, whence they recry-
lt at about 120° C. When anishydramide is acted on by
ite powder is obtained, which Cahours (Compt. rend.
Gerhardt (Traité, iii. 360) *hydride of sulphanisyl*. Its

ion of anishydramide, see HYDRAMIDES in art. AMIDES,

kept for two hours at a temperature between 165°
nto an isomeric alkaloid, to which the name *anisine* has
Ann. Ch. Pharm. lxxxviii. 128). In order to obtain
urity, it is dissolved in boiling alcohol, and hydrochloric
hen the hydrochlorate separates out in crystals. These
or, decomposed by potash or ammonia, and the free base is
hus obtained, anisine forms colourless transparent prisms,
or cold water, slightly soluble in ether, readily in alcohol.
ne reaction and a bitter taste. Anisine forms crystallisable
hlorate, $C^{24}H^{24}N^2O^3.HCl$, crystallises in colourless brilliant
vater, readily in alcohol. When dried at the ordinary
$C^{24}H^{24}N^2O^3.HCl + 9H^2O$; they give off water at 100° C.

The *chloroplatinate*, $2(C^{24}H^{24}N^2O^2.HCl).PtCl^4$, obtained by adding bichloride of pla
to the hydrochlorate, forms brilliant orange-coloured scales, slightly soluble in al
F. T

ANISIC ACID. *Hydrate of anisyl. Draconic acid*, &c. $C^8H^8O^3 = (C^8H^6O)''$.
(Cahours, Ann. Ch. Phys. [3] ii. 287; xiv. 483; xxiii. 351; xxv. 21; xxvii.
Laurent, Revue Scient. x. 6, 362; Gerhardt, Ann. Ch. Phys. [3] vii. 292.)—
acid, discovered by Cahours in 1841, is a product of the oxidation of anise
phor and of the crude oils of anise, fennel, and tarragon. The acids ob
from these several oils were at first distinguished by different names; but
identity is now clearly established. The first product of the oxidation of thes
stances is hydride of anisyl, which, by further oxidation, is converted into anisic
(See ANISYL, HYDRIDE OF.)

Cahours prepares anisic acid by boiling oil of anise with nitric acid of sp
gravity 1·2 (23° Baumé), when a yellow resinous substance (*nitranisside*) is fo
together with anisic acid, which crystallises from the acid liquid on cooling.
crystals are washed with cold water, and dissolved in ammonia; the ammoniu
is repeatedly crystallised till it is colourless, and then decomposed by acetate of
the difficultly soluble lead-salt is washed, and decomposed by sulphuretted hydr
and the anisic acid is dissolved from the sulphide of lead by boiling water, crystal
and purified (if necessary) by sublimation.

Laurent's method of preparing it from oil of tarragon is as follows:—1
together with a little water, is heated in a large retort, and 3 pts. common nitri
are added gradually. The mixture thickens by degrees, and is finally converted
a brown, resinous, slightly crystalline mass. This is washed, and extracted wit
dilute ammonia, which dissolves all but a small quantity of a brown substance.
ammoniacal solution is evaporated to a syrup, when it deposits a further porti
the brown substance, which was held in solution by the free ammonia: if the eva
tion be carried too far, the anisate and nitranisate of ammonium contained
solution may be partially decomposed. The syrup is mixed with water, boiled
filtered through animal charcoal; and the filtrate (neutralised, if acid, by amm
is evaporated, when anisate of ammonium crystallises in rhomboidal tables, whil
nitranisate remains in the mother-liquor. The anisate is recrystallised two or
times from alcohol, dissolved in a boiling mixture of alcohol and water, and
acid added to the hot solution, which, on cooling, deposits crystals of anisic
These are further purified by recrystallisation from boiling alcohol, and, if nece
by sublimation.

Anisic acid may also be prepared by dropping hydride of anisyl upon fused c
potash. A soft resinous mass is obtained, which, when dissolved in water
saturated with hydrochloric acid, deposits crystals of anisic acid, which are pu
as above. If hydride of anisyl be procurable, this is the most advantageous me
since the formation of nitranisic acid is entirely avoided. (Handwb.)

Anisic acid crystallises in brilliant colourless prisms, belonging to the mono
system, often of considerable size, with angles of 114° and 66°. The acute edge
mostly truncated; the base is replaced by two principal and three smaller face
has no taste or smell; is tolerably soluble in hot, but scarcely in cold, water; re
soluble in alcohol or ether, especially on boiling; its solution reddens litmus fe
It fuses at 175° C, and solidifies on cooling to a crystalline mass; at a higher
perature it sublimes without decomposition into snow-white needles.

It is isomeric with salicylate of methyl.

It is violently attacked by chlorine and bromine (see below, SUBSTITUTION-PRODU
Hot concentrated nitric acid converts it into nitranisic acid. Fuming nitric
converts it into dinitranisol or trinitranisol (see ANISOL), the product varying
the duration of the reaction and the proportion of the reagants. If heat be ap
a third substance, chrysanisic acid, isomeric with trinitranisol, is simultane
formed. A mixture of sulphuric and fuming nitric acids converts it into trinitra
Perchloride of phosphorus attacks it violently, forming chloride of anisyl, chl
phosphoryl, and hydrochloric acid. When distilled over caustic baryta, it is de
posed into carbonic anhydride and phenate of methyl (anisol).

$$C^8H^8O^3 = CO^2 + C^6H^5(CH^3)O.$$

Anisates. Anisic acid is usually considered as monobasic; but it is prob
diatomic, like glycollic and lactic acids. The general formula of the anisates is C^8H
(see ANISYL). They are mostly crystallisable: the alkaline and earthy salt
soluble, and the addition of a mineral acid separates anisic acid from their solutio

The *aluminium-salt* crystallises slowly in fine needles, when a dilute soluti
alum is added to anisate of ammonium.

The *ammonium-salt*, $C^8H^7(NH^4)O^3$, is very soluble, and crystallises in large rho

se are 84° and 96°. Exposed to the air, they become
vacuo, they lose ammonia, pure anisic acid being left

ared directly by boiling anisic acid with baryta, crys-
en in rhomboidal scales. Chloride of barium does not
m immediately, but after some time, a difficultly soluble

of calcium precipitates anisate of ammonium imme-
ilute, it crystallises in groups of needles.
white precipitate.
recipitate, composed of microscopic needles.
cipitate, soluble in hot water, whence it crystallises on
h retain ½ atom of water after drying at 120°.
le.
ises slowly from a mixture of sulphate of manganese and

d *zinc-salts* are white precipitates; the first crystallises
needles.
ses in rhomboidal or hexagonal tables; the *sodium-salt*

ecipitate, crystallising from hot water in fine needles, or

ses gradually in small hexagonal or rectangular laminæ,
strontium and anisate of ammonium.

urs, Ann. Ch. Phys. [3] xiv. 492.)

$^{10}O^3 = C^8H^7(CH^3)O^3$.—A mixture of 2 pts. anhydrous
and 1 pt. strong sulphuric acid, assumes an intense
plication of a gentle heat, wood-spirit first passes over,
olidifies in the receiver. This is anisate of methyl. It
t sodic carbonate, and with water, and recrystallisation
prepared, it forms large, white, shining scales, which
on cooling to a crystalline mass; at a higher temperature
has a faint smell, resembling that of oil of anise, and
ble in hot or cold water; readily soluble in alcohol or
Unlike salicylate of methyl, it does not combine with
iled with a strong solution of either alkali, is decomposed
alkaline anisate. Aqueous ammonia does not dissolve
it into methylic alcohol and anisamide, the latter of
ine, chlorine, and fuming nitric acid attack it violently,
yl-salts of the corresponding substitution-acid.

$^{12}O^3 = C^8H^7(C^2H^5)O^3$.—When a solution of 1 pt. anisic
lcohol is saturated at about 60° C. with hydrochloric acid
ined, whence water precipitates only anisic acid. On
hydrate, and finally anisate of ethyl pass over; and on
the latter product separates out as a heavy oil, which
ate, dried over chloride of calcium, and rectified over
rless oily liquid, heavier than water, with a smell like
m aromatic taste. It boils between 250° C. and 255°, is
uble in alcohol and ether. It may be kept unchanged
xposed to the air, it gradually becomes acid. Its decom-
ous to those of the methyl-salt.

itution-derivatives of Anisic Acid.

omodraconesic acid (Laurent). $C^8H^7BrO^3$.—When
d with bromine, heat is evolved, together with abundance
duct is washed with water, and crystallised from boiling
thus obtained in white shining needles, slightly soluble
alcohol or ether. It melts at 205° C., and sublimes in
istilled with lime, it yields carbonic anhydride and bro-
anisates are soluble; the potassium and sodium-salts
ation. In their solution, lead-, silver-, barium-, strontium-,
precipitates; the last three are not quite insoluble, but
ute solutions.
$H^6(CH^3)BrO^3$, is obtained by dropping bromine on the
wish-red product as in the case of bromanisic acid. Also

in the same manner as the anisate, bromanisic being substituted for anisic acid. The mixture is boiled in a water-bath for a quarter of an hour, and water added, when the bromanisate separates in flakes, which are washed with dilute ammonia and crystallised from hot alcohol. It forms colourless transparent prisms, which melt at a gentle heat: it is insoluble in water; soluble, especially on heating, in alcohol and wood-spirit; less soluble in ether. By boiling potash it is decomposed like the anisate.

Bromanisate of Ethyl, $C^8H^6(C^2H^5)BrO^3$, is obtained by the same process as anisate of ethyl, anisic being replaced by bromanisic acid; or by treating anisate of ethyl with bromine. It is purified in the same way as the methyl-salt. It forms long, white, shining needles, insoluble in water, soluble in alcohol or ether: it fuses at a gentle heat, and sublimes undecomposed. It is decomposed by boiling potash, and is not attacked by excess of bromine.

CHLORANISIC ACID, $C^8H^7ClO^3$, is obtained by passing chlorine over anisic acid in fusion; the product is washed with water, and crystallised from alcohol of 95 per cent. It forms fine shining needles, scarcely soluble in water, readily in alcohol or ether. It melts at about 176° C., and may be sublimed without decomposition. It is not acted upon by chlorine, even in sunshine. Strong sulphuric acid dissolves it by aid of gentle heat; it recrystallises from the solution on cooling, or is at once precipitated by water. When heated with baryta, it is decomposed like anisic acid. The metallic chloranisates resemble the corresponding bromanisates in solubility and general properties. The *chloranisates of methyl* and *ethyl* are obtained by submitting the corresponding anisates to the action of dry chlorine; the latter may also be prepared in a similar way to anisate of ethyl. Both are crystalline compounds, insoluble in water, soluble in alcohol or ether, and decomposed by boiling potash.

NITRANISIC ACID, $C^8H^7(NO^2)O^3$, is formed by the action of strong warm nitric acid on anisic acid. It is usually prepared by boiling oil of anise with nitric acid of specific gravity 1·33 (36° Baumé), until the oily substance which first forms has completely disappeared. The addition of water then precipitates yellowish flakes of impure nitranisic acid. This is purified by washing with water, dissolving in ammonia, recrystallising the ammonium-salt till it is colourless, dissolving it in water, precipitating the acid by nitric or hydrochloric acid, and washing it repeatedly with water. It is also formed in Laurent's process for preparing anisic acid from oil of tarragon, remaining in the ammoniacal mother-liquor whence anisate of ammonium has crystallised out. It is obtained thence by adding nitric acid, washing the precipitate, and boiling it for half an hour with nitric acid; the acid solution deposits on cooling short prisms of nitranisic acid, which are washed with water, and crystallised from hot alcohol. Nitranisic acid crystallises in small shining needles, of a slight yellow tinge, without taste or smell. It is scarcely soluble even in hot water; readily in alcohol or ether. It melts between 175° and 180°. When carefully heated further, it partly sublimes, partly blackens, and is decomposed; if heated suddenly, it decomposes at once, with evolution of light. It is not attacked by chlorine, bromine, or strong nitric acid; by fuming nitric acid, it is acted on in the same way as anisic acid. When heated with perchloride of phosphorus, it yields a dark yellow oil, with a very high boiling point, which is probably chloride of nitranisyl, $C^8H^6(NO^2)O^2,Cl$ (Cahours). An alcoholic solution of sulphide of ammonium converts it into anisamic acid (p. 291). According to Laurent (*loc. cit.*) nitranisic acid combines, atom for atom, with anisic, chloranisic, and bromanisic acids, forming peculiar dibasic acids.

The alkaline *nitranisates* are soluble and crystallisable: the ammonium-salt crystallises in fine needles, grouped in spheres; it is soluble in alcohol. The alkaline-earthy nitranisates are difficultly soluble; those of the heavy metals generally insoluble.

Nitranisate of methyl is prepared by a process analogous to that described in the case of anisate of methyl; or by dissolving anisate of methyl in fuming nitric acid, adding water, and crystallising the precipitate from alcohol. It forms beautiful large shining tables of a yellowish hue. It is insoluble in water; readily soluble in hot alcohol or wood-spirit, whence it separates almost completely on cooling. It melts at about 100° C., and sublimes undecomposed.

Nitranisate of ethyl is prepared either by dissolving anisate of ethyl in an equal volume of fuming nitric acid, or by a process analogous to that described in the case of anisate of methyl. In the latter case, the mixture must be kept at a temperature of 60°—70° C., while it is saturated with hydrochloric acid. The compound is precipitated by water, washed with dilute ammonia, and crystallised from alcohol. It exactly resembles the methyl-salt in appearance, and solubility in water and alcohol, and melts between 98° and 100° C. Strong sulphuric acid dissolves it in the cold, more readily on heating; it partly recrystallises as the solution cools, and is completely precipitated by water. Bromine exerts no action upon it.

$H^5(NO^2)^2O^3$, is obtained by treating anisic acid in the
ing nitric and fuming sulphuric acid, and diluting the
ts volume of water. It forms very beautiful salts with
monia and potash.

$^8O^3.SO^3$. (Zervas, Ann. Ch. Pharm. ciii. 339; Lim-
28.)—Obtained by heating anisic acid with common
ith fuming sulphuric acid to 100°, diluting the mixture
of lead, filtering at the boiling heat, and boiling the
as long as the filtered liquid yields crystals of the lead-
decomposed by sulphuretted hydrogen, yield the acid
anisic acid with sulphuric anhydride.

by slow evaporation of the aqueous solution, forms
in the air, and give off 6·9 per cent. (1 at.) water at
ecomposition below 170°. The aqueous solution may be

c. The *sulphanisates* of ammonium, potassium, and
he first in long slender needles. The *barium-salt*,
ained by saturating the acid with carbonate of barium,
ter drying over sulphuric acid, give off 16·9 per cent.
issolves easily in water, and is precipitated by alcohol.
y soluble needles. The *normal lead-salt*, $C^8H^6Pb''O^3.SO^3$
edles, which give off their water at 180° C. The *acid*
$2H^2O$, forms nodular crystals; easily soluble in water.
ar crystals, sparingly soluble in water. According to
he barium and lead-salts is diminished by repeated

F. T. C.

Hydrate of Anisalyl, $C^8H^{10}O^2 = C^8H^9O.H.O$. (Can-
Ann. Ch. Pharm. xcviii. 188.)—Formed from hydride
as benzoic alcohol from hydride of benzoyl. When
f anisyl in an equal volume of alcohol is mixed with
oholic potash of about 7° Beaumé (specific gravity
of heat takes place, and anisic alcohol and anisate
he latter in such quantity that the mixture shortly
($2C^8H^8O^2 + KHO = C^8H^7KO^3 + C^8H^{10}O^2$.) After 10
tilled off in a water-bath, and the residue is suspended in
ether. On evaporating the ethereal solution, a brown
ng the oil, anisic alcohol passes over at about 260°C., as
tallises on cooling. This product generally contains some
be detected by agitating it with a concentrated solution
e ANISYL, HYDRIDE OF). To purify it, it is treated again
oholic potash, distilled in carbonic anhydride, and the
etween filter-paper.

n hard, white, shining needles. It distils undecomposed
and melts at 23°, when anhydrous, but at much lower
It is heavier than water, has a faint spirituous, sweetish
ike that of oil of anise. At ordinary temperatures, it
but when heated nearly to its boiling point it, absorbs
to hydride of anisyl. Oxidising agents (as platinum-
t it, first into hydride of anisyl, then into anisic acid.
ith evolution of hydrogen. Sulphuric acid, even when
hosphoric anhydride, converts it into a resinous mass
it yields water, and an oily liquid, which solidifies on
t, vitreous mass, which melts at 100° C., and is insoluble
ble in bisulphide of carbon.

hloric acid gas, it forms water and a colourless liquid,
urning taste. This substance is its hydrochloric ether,
$^7O.Cl$, and is decomposed by alcoholic ammonia yielding
he hydrochlorates of anisamine and dianisamine (p. 297).
s analogy to salicylic acid, anisic acid be regarded as
s diatomic, $(C^8H^8).H^2.O^2$; and chloride of anisalyl will be

lic chlorhydrin. F. T. C.

E. $C^{16}H^{14}O^5 = C^8H^7O^2.C^8H^7O^2.O$. (Pisani, Ann. Ch.
the action of oxychloride of phosphorus on dry anisate of
with water, and the insoluble residue crystallised from
les, soluble in alcohol or ether, insoluble in water or

aqueous alkalis; it melts at 99°C., and distils at a higher temperature. By long boiling with water or aqueous alkalis, it is converted into anisic acid. F. T. C.

ANISIDINE (*Methylphenidine*, Gerh.) $C^7H^9NO = N.C^7H^7O.H^2$. (Cahours. Ann. Ch. Phys. [3] xxvii. 443.)—The action of sulphide of ammonium on the nitro-derivative of anisol gives rise to the formation of peculiar organic bases. Anisidine is obtained by dissolving nitranisol in an alcoholic solution of sulphide of ammonium, evaporating at a gentle heat to a quarter of its volume, adding a slight excess of hydrochloric acid to the brown residue, separating the sulphur by addition of water, and filtering. The yellow-brown filtrate deposits on evaporation, needles of hydrochlorate of anisidine, which are dried with filter paper and distilled with a strong solution of potash, when anisidine passes over with the aqueous vapour in the form of an oil, which solidifies on cooling.

The properties of anisidine but are imperfectly known. It combines with acids, forming salts. The *hydrochlorate* forms fine colourless needles, soluble in water and alcohol. When a hot concentrated solution of this salt is mixed with a concentrated solution of dichloride of platinum, the *chloroplatinate* separates on cooling in yellow needles. The *nitrate*, *sulphate*, and *oxalate* are crystallisable.

The products of the action of sulphide of ammonium on the higher nitro-derivatives of anisol may be regarded as nitro-derivatives of anisidine, though it is not known whether they can be formed by the action of nitric acid on anisidine.

NITRANISIDINE (*Methylnitrophenidine*, Gerh.) $C^7H^8N^2O^3 = C^7H^8(NO^2)NO$.—Prepared by a process similar to that described for anisidine, dinitranisol being substituted for nitranisol. The filtrate is mixed with ammonia, and the precipitate thus formed is washed with water, and crystallised from boiling alcohol. Nitranisidine forms long, garnet-red, shining needles, which are insoluble in cold, soluble in boiling, water; soluble in boiling alcohol, whence it separates almost entirely on cooling; also in ether, especially if heated. It melts at a gentle heat, and on cooling forms a radiated mass; when heated gradually to a higher temperature, it gives off yellow fumes, which condense into yellow needles. Bromine attacks it violently, forming a resinous mass, which has no alkaline properties. Fuming nitric acid decomposes it violently, yielding a viscous mass, insoluble in acids. The chlorides of benzoyl, cinnamyl, cumyl, and anisyl attack it when gently heated, forming hydrochloric acid, and compounds analogous to benzamide, which are described by Cahours under the names of *benzonitranisidide*, $C^{14}H^{12}N^2O^4 = N.C^7H^5O.C^7H^6(NO^2)O.H.$, *cinnitraniside*, $C^{16}H^{14}N^2O^4$, &c. These bodies are obtained pure by successively washing the products of these reactions with water, hydrochloric acid, and dilute potash, and crystallising from boiling alcohol; they are insoluble in water or in cold alcohol.

Nitranisidine dissolves readily in acids, and with many of them forms crystalline salts. The *hydrochlorate* and *hydrobromate*, when pure, form colourless needles, slightly soluble in cold, readily in boiling, water. The *chloroplatinate* separates in orange-brown needles from a mixture of hot concentrated solution solutions of the hydrochlorate and dichloride of platinum. The *sulphate* forms concentric groups of silky needles, readily soluble in water, especially in water containing sulphuric acid. The *nitrate* forms large needles, much more soluble in hot than in cold water.

Dinitranisidine (*Methyl-dinitrophenidine*, Gerh.) $C^7H^7N^3O^5 = C^7H^4(NO^2)^2NO$.—Prepared precisely like nitranisidine, trinitranisol being substituted for dinitranisol. When dry, it is an amorphous powder, of a bright red or violet-red colour, according to the concentration of the solution from which it was precipitated. It is almost insoluble in cold water, very slightly in hot water, forming an orange solution: slightly soluble in cold, moderately in hot alcohol, and separates on cooling in violet-black crystals; slightly soluble in hot ether. It melts at a gentle heat, and solidifies on cooling into a radiated, violet-black, crystalline mass. It is much less basic in its properties than the foregoing compound: it forms crystallisable salts with hydrochloric, nitric, and sulphuric acids, if the acids be employed in excess, but these compounds are decomposed by water. When heated with fuming nitric acid, it is violently attacked, and yields a yellowish brown resinous mass, which dissolves in potash, forming an intensely brown solution. F. T. C.

ANISINE. See ANISHYDRAMIDE.

ANISOIC ACID. $C^{10}H^{12}O^6$. (Limpricht and Ritter, Ann. Ch. Pharm. xcvii. 364.)—A product of the oxidation of oil of star-anise (probably also of oil of anise, tarragon, fennel, &c.). The oil is heated with nitric acid, of specific gravity 1·2, and the oily layer which sinks to the bottom of the mixture is agitated with a warm solution of acid sulphite of sodium, whence anisoate of sodium crystallises on cooling. To the purified crystals, enough sulphuric acid is added to decompose the salt, the whole eva-

cid extracted from the residue by absolute alcohol. It
olution in small laminæ, which have a strong acid reaction,
alcohol, and ether; they melt at about 120° C., and are
ition.

soluble. The *sodium-salt*, $C^{10}H^{17}NaO^6$, and the *barium-*
dules. The *silver*-salt forms soluble nodules, and speedily
F. T. C.

Ann. Ch. Pharm. cxvi. 169) regard this acid as identical
^{4},the product which they obtain by treating anise-cam-
ic gravity 1·106, then distilling and agitating the distil·
ium and alcohol. The atomic weights of the two acids
= 234; thianisoic acid = 230), so that the determina-
impricht and Ritter's analyses of the silver and barium-
rmula as well as with the other. Moreover in Limpricht
these salts, the amount of hydrogen found was much too
c acid (in the barium-salt 5·44 per cent., by calculation
r cent., calculation 4·98), and the absence of sulphur
experiment. (See Thianisoic Acid.)

Oil of.

thyl. Dracol. $C^7H^8O = C^6H^5(CH^3)O$. (Cahours, Ann.
53; xxvii. 439.)—This compound is formed by the
nisic acid, or on its isomer, salicylate of methyl: also
the substitution of methyl for 1 at. hydrogen. It may
Anisic acid distilled with excess of caustic baryta or
ssing over as a volatile oil: $C^8H^8O^3 + Ba^2O = C^7H^8O +$
follows when salicylate of methyl is dropped on finely
ture gently distilled. A third method is to heat phenate
nethyl in a sealed tube, to 100°—120° C. $C^6H^5KO +$
The product of either of these reactions is washed with
and rectified over chloride of calcium.

mobile liquid, with a pleasant aromatic smell. It is in-
in alcohol and ether, insoluble in potash. Its specific
boils at 152° C., and distils undecomposed. It is isomeric
ylic acid.

osphoric anhydride without decomposition. It dissolves
acid, and is not precipitated by water, a copulated acid
hich Cahours calls *sulphanisolic*, and Gerhardt *methyl-*
ormula $C^7H^8SO^4$. By saturating the acid liquid with
lline barium-salt is obtained, which contains 1 at. barium.
employed, not in excess, the addition of water separates
body, which Cahours calls *sulphanisolide*. Its formula
isolic acid as sulphate of ethyl is to ethyl-sulphuric acid.
y passing the vapour of sulphuric anhydride into arti-
ding water to the mixture; sulphanisolide is then de-
are recrystallised from alcohol, while sulphanisolic acid
s soft silvery prisms, insoluble in water, soluble in alcohol
tle heat, and sublimes undecomposed. Strong sulphuric
solic acid.

ives of Anisol.—Chlorine and bromine form with
n-compounds. The chlorine-compounds have not been
mine-compounds, *bromanisol*, C^7H^7BrO, and *dibromanisol*,
uble in boiling alcohol, whence it crystallises in brillant
nd at a higher temperature sublimes entirely in small

ergetically on anisol, forming three distinct nitro-com-
sol, and *Trinitranisol*, according to the proportions of the
the reaction. *Nitranisol*, $C^7H^7(NO^2)O$, is prepared by
small portions to anisol, the mixture being kept cool by
id is thus obtained, which is washed with dilute potash,
calcium. Anisol distils over first, and when the boiling
t 260° C., the receiver is changed. Nitranisol is a clear
r than and insoluble in water, with an aromatic smell,
almond oil. It boils between 262° and 264° C. It is
h, even on heating. When gently heated with strong
nd separates out again on the addition of water. When
d it is successively converted into di- and tri-nitranisol.

X

Dinitranisol, $C^7H^6(NO^2)^2O$, is prepared by boiling anisol for a few minutes with excess of fuming nitric acid: on adding water, a yellow liquid is separated, which soon solidifies into a yellow mass, which is recrystallised from boiling alcohol. It is also obtained by heating anisic acid to 90°—100° C., for about half an hour, with two or three times its weight of fuming nitric acid: chrysanisic acid forms at the same time, and is removed by dilute potash. Dinitranisol crystallises in long pale yellow needles, insoluble even in boiling water, soluble in alcohol and ether. It melts at about 86° C., and sublimes undecomposed. Aqueous potash does not attack it, even on boiling, unless the solution be very strong, and even then long boiling is required: when boiled with alcoholic potash, it is speedily decomposed, dinitrophenate of potassium being formed.

Trinitranisol, $C^7H^5(NO^2)^3O$, is formed when anisol, anisic, or nitranisic acid is heated with a mixture of equal parts of strong sulphuric and fuming nitric acid. Anisic acid is generally employed for its preparation. The mixture, which at first is clear and colourless, is gently heated till it begins to become turbid, carbonic anhydride being copiously given off. The heat is then removed, when there gradually collects on the surface an oil, which solidifies on cooling. A large quantity of water is then added, and the solid product is washed with boiling water, and crystallised from a mixture of equal parts of alcohol and ether. The reaction is complete if 15 pts. of the mixed acids be employed for 1 pt. anisic acid. Trinitranisol crystallises in yellowish, very brilliant tables, insoluble in water, soluble in hot alcohol or in ether. It melts at 58°—60° C., and if carefully heated, sublimes. Warm sulphuric or nitric acid dissolves without decomposing it. Aqueous ammonia or dilute potash, does not attack it, even on boiling; but moderately strong aqueous potash gives it an intense brown-red colour, and completely decomposes it on boiling, forming a slightly soluble potassium-salt of an acid, which is isomeric with, but, according to Cahours, distinct from picric, or trinitrophenic acid, which he designates picranisic acid.

All the nitro-derivatives of anisol are readily attacked by alcoholic sulphide of ammonium, sulphur being separated, and anisidine and its nitro-derivatives being formed.

F. T. C.

ANISULMIN. The name given by Brandes and Reimann to a brown product, obtained by extracting anise-seed, after previous treatment with alcohol, water, and hydrochloric acid, with aqueous potash, and precipitating the alkaline solution by acetic acid.

F. T. C.

ANISURIC ACID. $C^{10}H^{11}NO^4$.—An acid analogous to hippuric acid, produced by the action of chloride of anisyl on the silver-compound of glycocoll ($C^2H^4AgNO^2 + C^8H^7O^2Cl = AgCl + C^{10}H^{11}NO^4$). Acids, with aid of heat, convert it into glycocoll and anisic acid. (Cahours, Ann. Ch. Pharm. ciii. 90.)

ANISYL. $C^8H^7O^2$.—A hypothetical radicle, supposed to be contained in anisic acid, hydride of anisyl, and other anisic compounds. It may be regarded as salicyl, $C^7H^5O^2$, in which 1 at. hydrogen is replaced by methyl, $C^8H^7O^2 = C^7H^4(CH^3)O^2$: and, in fact, anisic acid and salicylate of methyl are not only isomeric compounds, but are both decomposed in the same manner by caustic baryta. Anisic acid is, therefore, to salicylic acid, as acetic is to formic acid. If, as Piria's recent researches (Ann. Ch. Pharm. xciii. 262) tend to show, salicylic acid be not monobasic but dibasic, the clear analogy between it and anisic acid, would probably lead to the conclusion that the latter acid is also dibasic; in which case, all anisic compounds must be regarded as containing a diatomic radicle, C^8H^6O, rather than a monatomic radicle, $C^8H^7O^2$.

BROMIDE OF ANISYL. $C^8H^7O^2.Br$. (Cahours, Ann. Ch. Phys. [3] xiv. 486.)—Prepared by dropping dry bromine (excess of which must be avoided), upon hydride of anisyl: heat is evolved, hydrobromic acid given off, and the mixture solidifies. The solid product is rapidly washed with ether, pressed between filter-paper, and crystallised from ether. It forms white, silky crystals, which are volatile without decomposition. Strong boiling potash gradually converts it into anisate and bromide of potassium.

CHLORIDE OF ANISYL. $C^8H^7O^2.Cl$. (Cahours, Ann. Ch. Phys. [3] xxiii. 351.)—When dry anisic acid is treated in a retort with pentachloride of phosphorus, a violent action takes place, and a mixture of products passes into the receiver. These are fractionally distilled, that part which boils between 250° and 270° C. being collected apart, washed with a little water, and rectified over chloride of calcium. Chloride of anisyl also seems to be formed by the action of chlorine on the hydride. It is a colourless liquid, with a strong smell: its boiling point is 262° C.; its specific gravity it 1·261 at 15°. When exposed to moist air, it is speedily decomposed into hydrochloric and anisic acids. In contact with dry ammonia, it evolves heat, and is converted into anisamide (*q. v.*). Alcohol and wood-spirit attack it energetically, forming hydrochloric acid, and anisate of ethyl and methyl respectively.

, $C^8H^8O^2 = C^8H^7O^2.H$. *Anisylwasserstoff; Anisylous*
isal. (Cahours, Ann. Ch. Phys. [3] xiv. 484; xxiii. 354.)
nisic acid, by the oxidation of oil of anise, or of anisic
the action of platinum-black is sufficient to produce the
gently heating oil of anise for about an hour, with three
cid of specific gravity 1·106 (14° Baumé): the heavy oil
ashed with dilute potash, and distilled. The distillate is
on of acid sulphite of sodium, of specific gravity 1·25; the
formed is collected on a funnel, thoroughly washed with
tle hot water as possible, and the solution heated with
onate, when the hydride of anisyl separates out and floats
urified by redistillation. The reaction is as follows, oxalic
rmed:

$$+ O^6 = \underset{\text{Hydride of anisyl.}}{C^8H^8O^2} + \underset{\text{Oxalic acid.}}{C^2H^2O^4} + H^2O$$

lowish liquid, with a burning taste, and an aromatic smell
its specific gravity at 20° C. is 1·09, and its boiling-point
insoluble in water, but soluble in all proportions in alcohol
ic acid dissolves it, forming a dark-red solution, whence it
When exposed to the air, it gradually absorbs oxygen, and
d; the same change is produced more rapidly by means of
platinum-black, or dilute nitric acid. Strong nitric acid
acid. Strong aqueous potash does not dissolve it till after
olic potash convert it into anisate, with evolution of hydro-
lcohol. Prolonged contact with caustic ammonia converts
.). Pentachloride of phosphorus attacks it energetically,
finally becoming a black pitchy mass, and a scanty distillate
loride of phosphoryl, together with a neutral oil having a

sses the property peculiar to aldehydes, of forming crys-
id sulphites of alkali-metal. *Sulphite of anisyl-sodium,*
rtagnini, Ann. Ch. Pharm. lxxxv. 268), is obtained by
ith a strong solution of acid sulphite of sodium: the mix-
e of butter, and finally becomes crystalline. When dried
ing alcohol, it forms colourless, shining scales; but it is
d during crystallisation. It is soluble in cold water, and
lphite of sodium, in which it is almost insoluble: its aque-
by boiling, hydride of anisyl being formed and sulphurous
nd alkalis decompose it also. Ammonia dissolves it, form-
lly solidify into crystals of anishydramide. Iodine and
y. The potassium- and ammonium-compounds are similar
th in mode of formation and in general properties. F. T. C.

ety of dolomite, CO^3CaMg, in which the magnesium is
d manganese. According to Berthier (Pogg. Ann. xiv
e compound with carbonate of sodium.

ee NICKEL-GREEN.

pering, Récuit, Anlassen.)—Many bodies when raised to a
ly cooled, become very hard and brittle. This is a great
d also in steel, when this metallic substance is required to
e inconveniences are avoided by cooling the substance very
is called annealing. Glass vessels, or other articles, are
rtment near the great furnace, called the *leer*, where they
ore or less quickly, according to their thickness and
mpering of steel, or other metallic bodies, consists simply
ring them to cool again, either upon the hearth of the
uation where the heat is moderate, or at least the tempera-
(See *Dictionary of Arts, Manufactures, and Mines*, i. 162.)

licles of the seeds of the *Bixa orellana*, a liliaceous shrub,
good ground, afford the red masses brought into Europe
anatto, arnatto, arnotto, orlean, and *roucou*.
met with in this country is moderately hard, of a brown
a dull red within. It is difficultly acted upon by water,
pale brownish-yellow colour. In rectified spirit of wine,
nd communicates a high orange or yellowish-red colour.

Hence it is used as an ingredient in varnishes, for giving more or less of an orange cast to the simple yellows.

Ether is the best solvent of annotto. Potash and soda, either caustic or carbonated, dissolve annotto in large quantity, from which solutions it is thrown down by acids in small flocks. The alkaline solutions are of a deep red colour. Chlorine decolorises the alcoholic solution of annotto, the liquid becoming speedily white and milky. If strong sulphuric acid be poured on annotto in powder, the red colour passes immediately to a very fine indigo blue: but this tint is not permanent, changing to green, and finally to violet, in the course of twenty-four hours. This property of becoming blue belongs also to saffron. Nitric acid, slightly heated on annotto, sets it on fire, and a finely divided charcoal remains. Annotto is soluble both in essential oils, as oil of turpentine, and in fixed oils. (Boussingault, Ann. Ch. Phys. xxviii. 440.)

Annotto contains a crystalline yellow colouring matter, called *bixin* (*q.v.*), which, when treated with alkalis, in contact with air, absorbs oxygen, and is converted into a red substance called *bixein*. Annotto is used in dyeing, but the colours produced by it are all fugitive; also for colouring cheese.—U. (See *Ure's Dictionary of Arts, Manufactures, and Mines*, i. 178.)

ANODE. Faraday's term for the positive pole or electrode in the voltaic circuit. (See ANION and ELECTRICITY.)

ANORTHITE. $Ca''O.SiO^2 + Al^2O^3.SiO^2 = (Ca\,al^2)Si^2O^8$.—A mineral belonging to the felspar family. It occurs in small crystals belonging to the triclinic system; also massive, with granular, columnar, or coarsely lamellar structure. Cleaves perfectly in two directions, inclined to one another at 85° 48′. Specific gravity 2·66—2·78. Hardness = 6—7. Transparent to translucent, with white, greyish or reddish colour, and vitreous lustre. Streak uncoloured. Fracture conchoïdal. Brittle. Before the blowpipe it melts, and forms with soda a milk-white enamel. Strong hydrochloric acid decomposes it completely, but does not gelatinise it.

Anorthite is found on Vesuvius and Somma, in the island of Procida, in Corsica, near Bogoslowsk in the Ural, on Hecla and in other localities in Iceland, in Java, in the island of St. Eustache in the Antilles, and in the meteorite of Juvenas. The follow-are analyses:

	G. Rose. Somma.	Deville. Antilles.	Damour. Hecla.	Waltershausen. Hecla.	Potyka. Ural.
SiO^2	44·49	45·8	45·97	45·14	46·79
Al^2O^3	34·46	35·0	33·28	32·11	33·16
Fe^2O^3	0·74	—	1·12	2·03	3·04
CaO	15·68	17·7	17·21	18·32	15·97
MgO	5·26	0·9	—	—	—
Na^2O	—	0·8	1·85	1·06	1·28
K^2O	—	—	—	0·22	0·55
NiO and CoO	—	—	—	0·77	—
Water	—	—	—	0·31	—
	100·63	100·2	99·43	99·96	100·79

The formula above given, which is that of an orthosilicate, requires 43·2 SiO^2, 36·8 Al^2O^3, 20·0 CaO.

The following are varieties of anorthite having nearly the same composition and crystalline form:—1. *Amphodelite* has the structure and specific gravity of anorthite; found at Logi, in Finland, and Tunaberg in Sweden.—2. *Bytownite*, from Bytown in Canada.—3. *Diploite* or *Latrobite*, from the island Amitok on the coast of Labrador. Rose-red, with the form, structure, and density of anorthite.—4 *Indianite*, from Hindostan. Granular masses, having the structure of felspar.—5. *Lepolite*, from Logi and Orijarfvi in Finland. Resembles amphodelite.—6. *Lindsayite*, from the same localities, appears to be the same altered, and containing a few per cent. of water. —7. *Polyargite*, from Tunaberg. Rose-red; granular; gives off water when heated, and becomes colourless.—8. *Rosellan*, from Aker, Södermanland. Exhibits similar properties.—9. *Sundvilkite*, from Kimito, Finland. Has the form of felspar; and specific gravity = 2·70.—10. *Wilsomite*, from Canada. Rose-red; specific gravity 2·76—2·77: hardness very different in different parts; becomes colourless when heated; gives off water and melts before the blowpipe, swelling up to a white enamel. (Dana, ii. 234; Rammelsberg's Mineralchemie, 590.)

ANOTTO. See ANNOTTO.

ANOXOLUIN. According to Leconte and Goumoens (Compt. rend. xxxvi. 834), fibrin, muscular fibre, albumin, vitellin, globulin. and casein, contain two different substances, one of which, called *oxoluin*, dissolves in glacial acetic acid, while the other, *anoxoluin*, is insoluble in that acid. In fibrin and muscular fibre, the

nguished, when examined by the microscope, by its fibrous
which is granular. Anoxoluin dissolves with reddish colour
hereas oxoluin dissolves but sparingly and with yellowish
pitated of a carmine-red colour by mercuroso-mercuric
red. Chromic acid dissolves anoxoluin at 100° C., forming a
oxoluin is not affected by it. Hydrochloric acid dissolves
a violet solution, the latter but sparingly, with yellowish
d solution of tartaric acid dissolves anoxoluin readily, but

he yellow colouring matter of the flowers of yellow toad-
ntirrhinum Linaria, L).—It may be prepared by treating
hol, evaporating to dryness, exhausting with water to dis-
ing the insoluble portion with alcohol, evaporating again
evaporating the ethereal solution, the colouring matter is
It melts when heated, and sublimes apparently without
alkalis dissolve it with red colour; ammonia and alkaline
colour: from these solutions it is precipitated yellow by
olve it with red colour, the solutions becoming yellow on
d aqueous solution is precipitated reddish-yellow by acetate
cupric-salts, orange-yellow by protochloride of tin. With
a pale yellow lake. The flowers of toad-flax are some-
w; stuffs dyed with them have a light yellow colour, but
r when exposed to the air. (Riegel, Pharm. Centralb.

ANIN. The blue colouring matter of flowers. (See

he white colouring matter of flowers. (See COLOURING

A mineral belonging to the amphibole family. (See

A native silicate of iron, found at Antonio Pereira, in
has an ochre-yellow colour inclining to yellow-brown,
ructure. Its composition, according to Schnedermann's
$^2O = 2Fe^2O^3.9SiO^2 + 2H^2O$.

The yellow colouring matter of flowers. (See COLOURING

NTHRACIN. Syn. with PARANAPHTHALIN.

nd coal, *Kilkenny coal*, or *Glance coal*.—There are three
conchoïdal of Jameson. Its colour is iron-black, some-
ace, with a resplendent lustre. Fracture conchoïdal, with
It is brittle and light. It yields no flame, and leaves
in the newest floetz-formations, at Meissner, in Hesse, and
-2. *Slaty anthracite*. Colour black, or brownish-black.
rection, with a slight metallic lustre. Brittle. Specific
nes without flame. It is composed of 72 carbon, 13 silica,
e of iron. It is found in both primitive and secondary
burgh; near Walsall, Staffordshire; in the southern parts
henshire, and Pembrokeshire, whence it is called Welsh
Kilmarnock, Ayrshire; and mostly abundantly at Kilkenny,
thracite. Small short prismatic concretions, of an iron-
ed metallic lustre. It is brittle, soft, and light. It yields
ns a thick bed near Sanquhar in Dumfriesshire; at Salt-
Ayrshire. It occurs also at Meissner in Hesse.—U. (See
Manufactures, and Mines.)

ANTHRACONITE, A variety of calc-spar or limestone,
brown, by coal and bituminous matter, occurring in certain
ilar formations containing vegetable and animal remains,
rtz, and at Christiania in Norway. When the bitumen pre-
alled *stinkstone*, from the property which it possesses of
racked, an odour like that of putrefying animal remains.

A fossil resin which occurs in layers of great extent, and
e strata of coal at Brandeisl, near Schlau in Bohemia. It
ss, but exhibits a hyacinth-red colour in thin layers; has

a shining surface, and conchoïdal fracture; is brittle, and yields a yellowish-brown powder. It melts and swells up strong when heated, and burns with a not unpleasant odour, leaving a residue of ferric oxide, lime, sulphuric acid, and silica. It appears to be a mixture of several substances. Ether dissolves a portion of it, leaving a resin, which has, according to Laurent, the composition $C^{40}H^{32}O^{18}$. The ethereal solution deposits after partial evaporation, a brown powder, containing $C^{40}H^{31}O^{7}$, and this, when exposed to the air, takes up oxygen, and becomes partially soluble in alcohol: and the alcoholic solution, precipitated with acetate of copper, yields a flocculent precipitate, containing oxide of copper, in combination with a resin, whose composition is expressed by the formula $C^{40}H^{34}O^{12}$. The portion left undissolved by the alcohol appears to contain $C^{40}H^{30}O^{8}$. (Handw. d. Chem. 2^{te} Aufl. ii. 39.)

ANTHRANILIC ACID. See Phenylcarbamic Acid.

ANTHROPIN. Heintz, in examining human fat, obtained, besides stearic acid, an acid which melted at 52° C., and gave by analysis numbers corresponding to the formula $C^{17}H^{34}O^{2}$. This he at first supposed to be a peculiar acid (anthropic acid) existing in the fat in the form of a glyceride (anthropin); but later investigations proved that it was a mixture of stearic acid with margaric or palmitic acid. (Pogg. Ann. lxxxiv. 238; lxxxvii. 233.)

ANTIARIN, $C^{14}H^{20}O^{5} + 2H^{2}O$.—The poisonous principle of the *Upas antiar*, a kind of green resin which exudes from the upas tree (*Antiaris toxicaria*), and is employed by the Javanese for poisoning their arrows. It is extracted by exhausting the upas with boiling alcohol, evaporating to dryness after the antiar-resin (see below) has deposited, treating the extract with water, and evaporating to a syrup; the antiarin then takes the form of scales, which are purified by recrystallisation. It is without odour, dissolves at 22°·5 C. in 251 parts of water, 70 parts of alcohol, and 2·8 pts. of ether; the solution is neutral to test-papers. It likewise dissolves in dilute acids. When dried at ordinary temperatures, it contains 13·4 per cent of water of crystallisation, which it goes off at 112° C. It melts at 220° C. into a colourless liquid, which assumes a vitreous aspect on cooling, and at a higher temperature turns brown, and exhales acid vapours. Dehydrated antiarin contains $C^{14}H^{20}O^{5}$ (62·69 p.c. C and 7·45 H.) Sulphuric acid colours antiarin brown. Hydrochloric and nitric acids dissolve it without alteration; so likewise do potash and ammonia.

Antiarin applied to a wound produces vomiting, convulsions, diarrhœa, and soon afterwards death; its poisonous action is remarkably accelerated by mixture with a soluble substance, such as sugar. (Mulder, Ann. Ch. Pharm. xxviii. 304.)

ANTIAR RESIN, $C^{16}H^{24}O$.—The *upas antiar* also contains a resin which does not exhibit any poisonous action. It is extracted by treating the upas with boiling alcohol or ether, and is deposited on cooling in white, odourless, glutinous flakes, having a density of 1·032 at 20° C., melting at 60°; insoluble in water; soluble in 325 pts. of alcohol at 20°, and in 44 pts. of boiling alcohol. Boiling ether dissolves ⅔ pt. of the resin. It dissolves readily in essential oils, and is sparingly dissolved by caustic potash. Its alcholic solution is not precipitated by alcoholic acetate of lead; but on adding water to the mixture, a plastic mass is precipitated containing 23·44 per cent. oxide of lead. (Pelletier and Caventou, Ann. Ch. Phys. xxvi. 57; Mulder, Ann. Ch. Pharm. xxvii. 307.)

ANTICHLOR. The application of alkaline hypochlorites (chloride of lime, &c.) to the bleaching of cotton and linen, is attended with this inconvenience, that the fibre is apt to retain a quantity of free chlorine, which gradually rots and destroys it. Hence the necessity of removing this free chlorine, either by long continued washing, or by the application of some reagent which can unite with the chlorine, and convert it into an innocuous compound. Such reagents are called "Antichlors:" their use is especially necessary in the paper manufacture, in which long continued washing involves a considerable waste of the pulp, and on the other hand, the non-removal of the free chlorine is attended with a gradual rotting of the goods after stowage, fading of the coloured quantities, and in some instances partial obliteration of documents written upon the paper thus imperfectly prepared, besides injury of the delicate machinery of the manufactory.

The first substances used for this purpose were the neutral and acid sulphites of sodium (sulphite and bisulphite of soda). A patent for this application of the acid sulphite was granted in 1847 to Mr. Henry Donkin, a manufacturer of papermaker's machinery, &c. at Bermondsey, and it was largely used till 1853, when it was superseded by *hyposulphite* of *sodium*, which is both cheaper to prepare and more efficacious, its practical value being just double that of the acid sulphite. (See Hyposulphites, under Sulphur.) The products formed by the action of chlorine, (or hypochlorous acid) on sulphite or hyposulphite of sodium, are sulphate and chloride of sodium, both of which are perfectly innocuous, and easily removed by washing.

removal of the free chlorine, the bleached paper or other
r which runs from it, must be tested with a mixture of
rch: the slightest trace of chlorine will be indicated by a
hether an excess of the antichlor has been used, add to the
le of potassium a few drops of the bleaching liquid, so as
and then add a portion of the liquid to be tested; if
xcess, the colour will be destroyed.
red by boiling sulphur with milk of lime, has also been used
has a solution of protochloride of tin in hydrochloric acid;
r, it is necessary, after the completion of the bleaching
f sodium, in order to neutralise the free hydrochloric acid,
as injuriously as the free chlorine itself. The precipitate
duced is quite white and soft, and does not interfere with
e paper manufacture.
used since 1818, as an antichlor in paper making; it does
e so convenient as the reagents above-mentioned. (See
y of Arts, Manufactures, and Mines.)

THEORY. See CHLORINE.

ydrated silicate of magnesium belonging to the serpentine
f Antigoria in Switzerland. (See SERPENTINE.)

See ANTIMONY, OXIDES OF.

PER. Native sulphide of copper and antimony, or Wolfs-
PHIDES OF.)

PPER GLANCE. Also called *Wolchite.*—A mineral
t St. Gertraud, in Carinthia. Short rhombic prisms with
rachydiagonal, imperfect; also massive. Specific gravity
Colour blackish lead-grey. Fracture conchoïdal, to uneven;
g to Schrotter's analysis, 28·60 S, 16·5 Sb, 6·04 As, 29·50
95·94. (Dana, ii. 82.)

CUS. See ANTIMONY, OXYSULPHIDE OF.

D ORES. See LEAD, SULPHIDES OF.

CKEL, and **ANTIMONIAL SILVER.** See ANTI-

LPHIDE of SILVER. See SILVER, SULPHIDE OF.

tive Sulphide of Antimony.

See ANTIMONY, OXIDES OF.

ssglanzmetall, Spiessglassmetall, Antimoine, Antimonium,
omic weight (as determined by the recent experiments of

of antimony were known to the ancients; but the method of
was first described by Basilius Valentinus towards the end

e, and alloyed with other metals; viz. with arsenic, nickel,
ation with oxygen; viz. as trioxide, in the form of *antimony*
Valentinite, Sb^2O^3 and as tetroxide, *antimony ochre*, or
nbination with sulphur, as *stibnite* or grey *antimony ore*,
oxygen, as *red antimony*, *antimony blende*, or *kermesite*
hide combined with various other metallic sulphides, chiefly
g. zinkenite, $Pb^2S \,.\, Sb^2S^3$; *miargyrite*, $Ag^2S.Sb^3S^3$, &c. (See
tly it occurs in ferruginous water, associated with arsenic,

antimony of commerce is obtained from the native tri-
many localities among the older rocks, gneiss, clayslate,
de is first separated from its gangue by fusion (p. 329), then
sting, and the oxide is subsequently reduced by coal or char-
once reduced to the metallic state by fusion with a mixture
with metallic iron. The following details are taken from
v. p. 318.
hide of antimony, mixed with about half its weight of
t caking, is roasted at a gentle heat (on the small scale, on a

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omic weight of antimony at 129, which number was for a long time
m. lxviii. 115, 376) obtained the number 120·7; Dexter (Pogg Ann.
See page 321.)

roasting dish; on the large scale, in a reverberatory furnace), with constant stirring, the fire being gradually increased, but not sufficiently to fuse the mass. The sulphur escapes in the form of sulphurous acid, and there remains a mixture of tetroxide of antimony with a small quantity of trioxide, amounting to about ⅘ of its weight (Geiger and Reimann, Mag. Pharm. xvii. 136), and traces of undecomposed sulphide of antimony: *Antimony-ash*, *Calx Antimonii grisea per se*, or *Cinis Antimonii*. This residue is then mixed with half its weight of cream of tartar, or with 1 part of charcoal and ½ pt. potash, or with charcoal powder saturated with an aqueous solution of carbonate of sodium, and fused in a covered crucible at a low red heat; the fused mass is then poured out into a hot mould partly filled with tallow, and the mould gently tapped to make the metal sink to the bottom. The slag at the top consists of a mixture of alkaline carbonate, double sulphide of antimony and potassium (or sodium) and charcoal. The charcoal separates the oxygen from the antimony, and from a portion of the alkali; and the potassium or sodium thus eliminated separates the sulphur from part of the sulphide of antimony still present, and then, in the form of sulphide, unites with the remainder.—2. A mixture of 8 parts of sulphide of antimony, and 6 parts of cream of tartar is heated in a crucible, nearly to redness, and from 2 to 3 parts of nitre are added till the mass becomes perfectly fused. Or a mixture of 8 pts. of sulphide of antimony, 6 pts. of cream of tartar, and 3 pts. of nitre, is projected by small portions at a time into a red-hot crucible placed in a furnace, and the whole is heated for a short time, till perfectly fused. The mass is then poured out as before. The lower stratum consists of metallic antimony; the upper, of double sulphide of antimony and potassium mixed with charcoal. The charcoal in the black flux withdraws oxygen from the potash; the potassium thus separated decomposes a portion of the sulphide of antimony, setting the metal free; and the resulting sulphide of potassium unites with the still undecomposed sulphide of antimony. Probably according to the following equation:

$$5Sb^2S^3 + 6K^2O + 6C = 3(2K^2S.Sb^2S^3) + 4Sb + 6CO.$$

According to this, only ⅖ of the antimony contained in the sulphide should be obtained in the metallic state, or from 100 parts of the sulphide of antimony, 29·15 parts of regulus. This result accords with actual experience, 100 parts of sulphide of antimony being found to yield 27 parts of antimony. According to Liebig, however, by leaving out the nitre in this process, 100 parts of sulphide of antimony produce 45 parts of the metal.—3. An intimate mixture of 8 parts of sulphide of antimony with 1 pt. of dry carbonate of sodium and 1 pt. of charcoal, heated in an earthen crucible, and constantly stirred with a stick till it fuses quietly, and then poured out into the casting mould, yields 5·7 parts (71 per cent.) of antimony, which is afterwards purified from iron and copper by fusion with ⅛ its weight of nitre (Duflos, Br. Arch. xxxvi. 277; xxxviii. 158). In this process, rather more than 3 atoms of carbonate of sodium and charcoal are used to 1 atom of trisulphide of antimony, so that a sufficient quantity of sodium is set free to separate the whole of the sulphur:

$$Sb^2S^3 + 3Na^2O + 3C = 2Sb + 3Na^2S + 3CO.$$

The fusion must be continued for a long time, during which the mass is very apt to boil over, and the antimony to burn away; the total amount obtained is only 66 per cent., and the antimony still contains the whole of the other metals which were present in the sulphide (Liebig, Mag. Pharm. xxxv. 120).—4. A mixture of 177 pts. (1 at.) of sulphide of antimony with at most 82 pts. (3 at.) of iron filings or iron nails is heated to bright redness in a closely covered crucible, and then left to cool:

$$Sb^2S^3 + 3Fe = 2Sb + 3FeS.$$

The iron separates the whole of the sulphur, even at a gentle heat; but a stronger heat is required to fuse the sulphide of iron, and cause the antimony to form a distinct stratum beneath it; at this high temperature, the antimony is apt to burn away if the crucible be not well covered; hence a layer of charcoal powder over the mixture is useful.—The addition of carbonate of potassium or sodium, or of nitre, accelerates the fusion, because double sulphide of iron and potassium or sodium is thereby formed, which is more readily fusible than pure sulphide of iron. For example, 22 pts. of nitre are added to a strongly ignited mixture of 100 pts. of sulphide of antimony and 33 pts. of iron, or 6 pts. of nitre to 100 pts. of sulphide of antimony and 47 pts. of iron;—or 100 pts. of sulphide of antimony, 43 pts. of iron, from 10 to 50 pts. of dry carbonate of sodium, and 2 to 5 pts. of charcoal are melted together. Berthier, however, found it most advantageous to fuse together 100 pts. of sulphide of antimony, 55–60 pts. of smithy scales, 45 pts. of carbonate of potassium, and 10 pts. of charcoal: this mixture yielded 69 pts. of antimony; the mass, however, was found to froth up considerably. Liebig (Mag. Pharm. xxxv. 120) gives the preference to this method: but the regulus which it separates from sulphide of antimony containing lead is contaminated with that metal (Ann. Ch. Pharm. xxii. 62). A mixture of 100 pts. of

of iron, 10 parts of dry sulphate of·sodium, and $2\frac{1}{2}$ pts. of
nd 64 pts. of antimony (**Liebig**).—The slag obtained
se yields a large quantity of antimony by fusion with
ide of antimony and potassium is thereby converted into
otassium.

irst, second, and third processes,—the *Regulus Antimonii*
idifies in the mould, and has a stellated structure on the
been called *Regulus Antimonii stellatus*,—may contain
lead, iron, and copper; the antimony prepared by the
nonii martialis, may contain a large quantity of iron,
been used in excess. The powdered antimony may be
ith sulphide of antimony; from sulphur, by fusion with
sulphur and potassium, by fusion with nitre; and, ac-
lphur, potassium, arsenic, and iron, by fusion with from
le.

mony, or the slag obtained in the second process, with
n antimony is obtained, which may contain small quan-
ny thus prepared was formerly called *Regulus Antimonii*
lunaris, &c.

ollowing method, commercial antimony and likewise that
nay be perfectly freed from sulphur, arsenic, iron (when
nd copper, but not from lead: hence the antimony sub-
l be free from lead. A mixture of 16 pts. of coarsely
of grey sulphide of antimony and 2 pts. of dry carbonate
n crucible for an hour, care being taken to prevent any
mass. When cold, the crucible is broken, and the slag
e metal, which is again coarsely pulverised, fused with
for an hour, and, lastly, after cooling and removal of the
t. of carbonate of sodium. In this manner 15 pts. of pure
g, Ann. Ch. Pharm. xix. 22). The sulphide of antimony
ept the lead, into metallic sulphides, which pass into the
hide of sodium. The remaining arsenic is separated by
e form of arsenate of sodium. If any charcoal falls into
c from the arsenate of sodium, whereby the antimony is
big). Hence a black-lead crucible cannot be used;
dium, which then mixes with the antimony (**Anthon**,
mercial antimony has been prepared with iron, and is
larger quantity of sulphide of antimony must be added
ay, in proportion nearly corresponding to the iron (4 pts. of
ts. of carbonate of sodium, to 16 parts of the antimony):
nony is greater. As long as iron is present, it is impos-
by means of carbonate of sodium (**Liebig**, Ann. Ch.
rb. 2te Aufl. ii. 45; see also **Buchner**, Repert. li. 267).
algaroth is reduced with alkali and charcoal. By this
heavy metals are got rid of. **Artus** (J. pr. Chim. viii.
owdered grey sulphide of antimony or glass of antimony,
pts. of oil of vitriol and 2 pts. of water for eight hours,
afterwards mixes the liquid with water till a permanent
; then filters; precipitates the powder of algaroth by
it thoroughly, and fuses 100 parts of the dry compound
e of sodium and 20 pts. of charcoal-powder for fifteen or
ure antimony are thus obtained.—3. A very pure metal
tartrate of antimony and potassium (tartar-emetic) to
the resulting metallic mass in water, to remove any
n reduced at the same time. (**Capitaine**, J. Pharm. xxv.
449.)

nly.—The extensive use of antimonial preparations in
l of this impurity a point of particular importance.—
nmercial antimony are mixed with five pts. of nitre and
dium (without the latter, insoluble arsenate of antimony
ixture is projected into a red-hot crucible. The mass
on (which takes place quietly) is then pressed together,
higher temperature, so that it may become pasty but not
ften as it swells up from evolution of gas. After this, it
ith the spatula, while still hot and soft, then reduced to
time in water, with frequent stirring. The water, to-

gether with the finer powder, is then poured off; the coarser powder crushed with a pestle, and boiled with a fresh quantity of water; the two liquids with their deposits are mixed; and the insoluble portion is freed by repeated subsidence and decantation, and, lastly, by washing on a filter, from the alkaline solution which contains the alkaline arsenate and but a very small quantity of antimonate. The washed acid antimonate of potassium is white; but if it contains lead, which cannot be removed by nitric acid, it has a yellow colour. It is then fused with half its weight of cream of tartar at a moderate red heat, and the resulting metallic antimony containing potassium is pulverised and thrown into water, which removes the potassium and liberates pure hydrogen gas (Wöhler, Pogg. Ann. xxvii. 628; also Ann. Ch. Pharm. v. 20.) According to C. Meyer (Ann. Ch. Pharm. lxvi. 236; Centr. Blatt. 1348, 828) the use of nitre is objectionable, because it gives rise to the formation of antimonate of potassium, which destroys the exactness of the process. Meyer recommends a mixture of nitrate and carbonate of sodium, whereby a mass is obtained which does not yield a trace of antimony to water. This method is so exact that it may be used to separate antimony from arsenic in quantitative analysis; moreover, the antimony thus obtained is not contaminated with potassium or sodium. — 2. One part of pulverised antimony, prepared by the second method (p. 312), is rapidly fused with half its weight of carbonate of potassium, and the mass is poured out; the metal obtained is then crushed, fused with one-fourth its weight of nitre, again poured out, the metal again crushed, and fused with one-third its weight of hydrated antimonic acid; and lastly, the antimony, after being repulverised, is fused with one-third its weight of carbonate of potassium, and poured into the mould. This method completely removes the arsenic (Th. Martius, Kastn. Arch. xxiv. 253). — 3. If 32 pts. of antimony, rich in arsenic, are fused with 4 pts. of nitre, the slag contains a large quantity of arsenate of potassium; and the resulting 30 pts. of metal fused with 3 pts. of nitre, still yields a small quantity of arsenate of potassium and 27 pts. of metal; this, if again fused with 2 pts. of nitre, yields a slag containing scarcely anything but antimonate of potassium, and metallic antimony perfectly free from arsenic. If carbonate of potassium be used instead of nitre, the separation of the arsenic is much more difficult (J. A. Buchner, Repert. xliv. 246). — 4. One part of antimony prepared by the third method, is heated with 1½ pt. of oil of vitriol in a porcelain basin, stirring constantly as long as sulphurous acid gas continues to be evolved, and water is carefully added by small portions at a time, till a greyish-white intumescent mass is formed. This is then mixed in a vessel made of antimony, with from 0·2 to 0·4 pt. finely powdered fluor-spar, and 0·4 to 0·8 pt. oil of vitriol (according to the quantity of arsenic present). The whole is then heated, with constant stirring, as long as hydrofluoric acid and fluoride of arsenic are given off; the residue is afterwards gradually mixed with water, and washed by decantation till the wash-water ceases to exhibit an acid reaction; and the remaining basic sulphate of antimony is reduced by fusion with half its weight of cream of tartar, in a covered crucible. If a leaden vessel were used, antimony and arsenic would be reduced together, and consequently the antimony obtained would not be free from arsenic. (Duflos, Kastn. Arch. xix. 56; also, Schw. lx. 353; further, Schw. lxii. 501; see also Buchner and Herberger, Repert. xxxviii. 381, xliv. 246.)

Tests for Impurities in Antimony. — 1. *Sulphur.* The powdered metal, when heated with strong hydrochloric acid, gives off hydrosulphuric acid. — 2. *Potassium* or *Sodium.* The antimony appears more grey than white, and loses its lustre on exposure to the air. Its powder has an alkaline taste, reddens moist tumeric paper, and evolves hydrogen gas when put under water, giving up alkali to the liquid. — 3. *Arsenic.* The metal, when fused in the air, emits a garlic odour. If its powder be detonated with about ¼ pt. of nitre, and the resulting mass treated with water, a filtrate is obtained, which contains arsenate and antimonate of potassium, so that when supersaturated with hydrochloric acid, and rapidly saturated with hydrosulphuric acid gas, it first gives a yellowish red precipitate of pentasulphide of antimony, and then, if rapidly filtered and preserved in a close vessel, gradually deposits a yellow precipitate of pentasulphide of arsenic. The antimony ignited with an equal weight of cream of tartar in a covered crucible, yields an alloy of potassium, arsenic, and antimony, which, if reduced to powder under water, evolves arsenietted hydrogen, recognisable by its depositing brown metallic arsenic on ignition (see ARSENIC). — 4. *Lead.* The powdered metal boiled with nitric acid nearly to dryness, and then treated with water, yields a filtrate which contains nitrate of lead, and is consequently precipitated by sulphuric acid. When the quantity of lead is large, a solution of antimony in aqua-regia deposits crystalline needles of chloride of lead on cooling. — If the antimony contains sulphur besides the lead, the lead remains undissolved in the form of sulphate, on treating the metal with nitric acid. If the antimonious oxide in the residue is then dissolved out by warm hydrosulphate of ammonia, black sulphide of lead remains

, black sulphide of iron also. — 5. *Iron.* The finely
ee times its weight of nitre, and washed with boiling
ue, from which boiling dilute hydrochloric acid sepa-
y be detected by ferrocyanide of potassium, &c. —
s been precipitated from the nitric acid solution by
he method above given, the cupric oxide remains
ed by its behaviour with hydrosulphuric acid, ferro-
, or polished iron. A solution of antimony in aqua-
ed precipitate with sulphide of ammonium, perfectly
pitant. If a black residue is left, it must consist of
r. (H. Rose.)

brilliant metal, having a bluish-white colour, and
y melting it in a crucible, then leaving it to cool par-
liquid portion, it may be obtained in rhombohedral
allise is well shown in the cakes of metal which are
ace of which often exhibits beautiful stellate or fern-
rom 6·702 to 6·86. It is very brittle, and easily pul-
at 450° C. (842° Fah.), and may be distilled at a white
gen, but the distillation is very slow, in consequence of
. Metallic antimony occurs native in small quantity,
ystals, at Andreasberg in the Harz, at Przibram in
d at Allemont in France.
imony is deposited from its solutions by electrolysis in
us precipitated, with a positive electrode of antimony,
rtar emetic and 5 pts. of tartaric acid dissolved in a
acid and 30 pts. water, it has a silvery-grey colour and
re, has a radiating crystalline structure, and a density
1 pt. of tartar emetic in 4 pts. of the ordinary chloride
of hydrochloric acid ?) it is deposited with the colour
eel, and a bright, metallic, amorphous fracture. Its
8. This amorphous antimony, when heated or struck,
molecular change throughout its mass, attended with
° to upwards of 450° F.), increasing at the same time
colour and structure to the crystalline variety. At the
ide of antimony and of gas, condensed within its pores
e force, is given off. No such change takes place in
y carefully triturating thin pieces of the amorphous
btained in the state of a fine powder, exhibiting the
ioned. This change of antimony from the amorphous to
be similar to that which has been observed in sulphur,
. (G. Gore, Proc. Roy. Soc. ix. 70.)
c. Roy. Soc. ix. 304), Mr. Gore states that the evolu-
change "is not limited to a particular temperature,
and 190° F., and increases in rapidity to some point
es sudden. The heat may be discharged either sud-
to the amount to be discharged relative to the cooling
ic heat of the unchanged (amorphous) metal was found
me specimens, after being gradually discharged, the
ifferent. But the specific heat of the substance, after
be 0·0543. The total amount of heat evolved by the
as sufficient to raise the temperature of its own weight
c heat = 0·0508) about 650 F." An acid solution of
electro-deposition, crystalline antimony not possessing

tered by exposure to the air at common temperatures,
ted. At a red heat, it takes fire, burning with a white
nes of the trioxide. A lump of the pure metal heated
pe, burns brilliantly, emitting copious white inodorous
ore it is completely burnt away, becomes covered with
llised oxide. If, on the contrary, the antimony is con-
ron, it exhales a garlic odour, especially at the com-
with a slag of oxide of iron; has a dull surface;
lowpipe flame is withdrawn; and yields a yellow oxide.

ed and oxidised by *nitric acid*, but not dissolved. The
h the strength of the acid. If the acid be moderately

dilute, the product consists of trioxide of antimony, mixed with a small quantity of pentoxide; with strong nitric acid, on the contrary, the product consists chiefly or wholly of pentoxide (H. Rose, Analyt. Chem. i. 258). The metal is not acted upon by dilute *sulphuric acid*, but when heated with the strong acid, it is converted into sulphate, with evolution of sulphurous anhydride. In the state of fine powder, it is dissolved by boiling *hydrochloric acid*, with evolution of hydrogen, but in the compact state, it resists the action of that acid, even at the boiling heat.

Antimony forms, with acid or chlorous radicles, two classes of compounds, viz.

1. *Antimonious compounds* or *tri-compounds of antimony*, containing 1 atom of the metal with 3 atoms of a monobasic acid-radicle, Cl, Br, &c. or 2 atoms of metal with 3 atoms of a dibasic acid radicle, O, S, &c., *e.g.*:

Trichloride of antimony	$SbCl^3$
Trioxide or antimonious oxide	Sb^2O^3
Trisulphide	Sb^2S^3

2. *Antimonic compounds* or *penta-compounds of antimony*, in which 1 or 2 atoms of metal are associated with 5 atoms of an acid-radicle, *e.g.*:

Pentachloride of antimony	$SbCl^5$
Pentoxide or antimonic oxide	Sb^2O^5
Pentasulphide	Sb^2S^5

In the antimonious compounds, $Sb = H^3$; in the antimonic compounds, $Sb = H^5$.

There are likewise a few compounds of antimony not included in either of these series; *e.g.* the tetroxide, SbO^2, which may, however, be regarded as a compound of the two oxides above mentioned, viz. antimonoso-antimonic oxide, $Sb^2O^3.Sb^2O^5 = 4SbO^2$.

ANTIMONY, ALLOYS OF. Antimony unites with most of the heavy metals, rendering them harder and more brittle. Most of the alloys are easily formed by fusing the two metals together; some occur native. The alkali-metals likewise form alloys with antimony.

For the compounds of arsenic and antimony see ARSENIC.

Antimonide of Copper.—Prepared by fusing the two metals together in equal quantities is pale violet, very brittle, and of laminar texture. According to Karsten, copper alloyed with 0·15 per cent. of antimony, becomes somewhat cold-short and very hot-short.

Antimonide of Gold.—The two metals unite very easily, melted gold even absorbing vapour of antimony. An alloy of 9 pts. gold to 1 pt. antimony is very brittle, white, and exhibits the fracture of porcelain. Gold loses its malleability by admixture with about $\frac{1}{2000}$ of antimony. The antimony is easily expelled from the alloy by heat.

Antimonide of Iron.—A mixture of 7 pts. of antimony, and 3 pts. of iron heated to whiteness in a crucible lined with charcoal, forms a white, very hard, slightly magnetic alloy, which gives sparks when filed. An alloy of antimony and iron is always formed when sulphide of antimony is reduced by iron in excess (*regulus antimonii martialis*). A very small quantity of antimony (0·23 per cent.) makes refined iron both hot- and cold-short.

Antimonide of Lead.—The two metals unite readily in all proportions. Lead is hardened by admixture with antimony. An alloy of equal parts of the two is brittle and ringing; 12 pts. lead and 1 pt. antimony form a malleable alloy, somewhat harder than lead. *Type-metal* is an alloy of antimony and lead, usually containing 17 to 20 per cent. of antimony. Sometimes other metals are added, *e.g.* 1 pt. bismuth to 10 pts. lead and 2 pts. tin, or, for stereotype plates, $\frac{1}{80}$ to $\frac{1}{10}$ of tin. The specific gravity of alloys of lead and antimony is always above the mean.

Antimonide of Nickel, $NiSb^2$, occurs as a metallurgic product obtained by sublimation in long hexagonal prisms. Another alloy, Ni^2Sb, occurs as a natural mineral called *antimonial nickel* or *Breithauptite*, in thin hexagonal plates of specific gravity 7·541, hardness 5·5; fracture uneven; the recent fracture exhibits a light copper colour with a tinge of violet; powder red-brown. Not magnetic. Ignited in a glass tube, it yields a small sublimate of antimony. On charcoal it forms an antimonial deposit, and cannot be fused excepting in small pieces. It is but little attacked by simple acids, but dissolves easily in aqua-regia. Analysis by Stromeyer (Pogg. Ann. xxxi. 134):

Sb	Ni	Fe	PbS	
63·73	28·95	0·87	6·44	= 99·99
59·71	27 05	0·84	12·36	= 99·96

Andreasberg mountains, with calc-spar, galena, and
g been exhausted. A similar alloy may be obtained
with 1 at. Sb. (Dana, ii. 53.)
loy is easily formed by fusing the two metals together,
imony with tin (*regulus antimonii jovialis*). Britannia
and 1 pt. antimony, frequently also containing small
copper, zinc, and bismuth. Alloys of antimony with
lso containing copper, are now much used for machinery
. (See *Ure's Dictionary of Arts, Manufactures, and*

nony forms with zinc, alloys of definite crystalline
the two metals, containing from 43 to 70 per cent. of
, silver-white rhombic prisms, containing from 43 to
containing exactly 43 per cent. of zinc, appears to be
ncyl, Sb^2Zn^3. Mixtures containing from 33 to 20 per
ystals containing from 35 to 21 per cent. of zinc. The
cent. is *stibiodizincyl*, Sb^2Zn^2. These alloys, especially
evolution of hydrogen at the boiling heat, and very
acids. (J. P. Cooke, Sill. Am. J. [2] xviii. 229; xx.

Alloys of antimony and potassium may be obtained by
er, or by igniting metallic antimony, or its oxide or
f potassium. Thus, when 5 pts. of crude tartar and
heated in a covered crucible till the mixture becomes
ess for an hour, and left to cool, a crystalline regulus is
. of potassium. This alloy decomposes water rapidly,
hen in the compact state, but becomes heated and takes
Löwig and Schweizer.)
Sb and Ag^6Sb occurs native as *antimonial silver* or
ed prisms with truncated lateral edges; also in scaleno-
c-spar. Specific gravity 9·4 to 9·8; hardness 3·5 to 4;
Before the blowpipe, it gives off fumes of antimony,
e, metallic globule; by continuing the heat on charcoal,
in nitric acid, leaving oxide of antimony. Analysis by

	Ag^4Sb		Ag^6Sb
	a.	*b.*	*c.*
y . .	24	24	16
. . .	76	76	84
	100	100	100

y from Wolfach, in Baden; *b* lamino-granular, from
fine-grained, from Wolfach. The mineral occurs also
llemont, in Dauphiné; at Casalla, in Spain; and near
m. vi. 199; Dana, ii. 35.)
nbles antimonide of potassium, and is prepared in like

Native trioxide of antimony.

E OF. $SbBr^3$.—This is the only known compound of
formed by direct combination. Antimony takes fire in
with liquid bromine, running about on the surface in
the compound, bromine is put into a retort, and dry
ed through the tubulus, agitating each time till the
product is then purified by distillation. It forms on
edles, deliquescent, melting at 90°C., volatile at 270°.
an oxibromide.

DES OF. Antimony and chlorine unite directly when
antimony is in a state of fine division, the combination
bustion. The compound formed is a trichloride or a
antimony or the chlorine is in excess.

ONY, $SbCl^3$, is obtained:—1. By passing chlorine gas
ing excess of antimony, or over heated trisulphide of
hur formed at the same time being afterwards volatilised

by a gentle heat. 2. By distilling 3 pts. of antimony with 8 pts. of mercuric chloride, or 2 pts. of the trisulphide of antimony with 4·6 pts. of mercuric chloride:

$$2Sb + 3Hg''Cl^2 = 2SbCl^3 + 3Hg;\ \text{and}\ Sb^2S^3 + 3Hg''Cl^2 = 2SbCl^3 + 3Hg''S.$$

3. By heating the trisulphide with strong hydrochloric acid, or metallic antimony with hydrochloric acid to which nitric acid is added in successive small portions: if too much nitric acid were added, a precipitate of oxide of antimony or antimonic acid would be formed. A solution of the trichloride in excess of hydrochloric acid is thus formed, and on subsequently distilling this liquid, water and hydrochloric acid pass over first, and afterwards the pure trichloride.

Trichloride of antimony is at ordinary temperatures a translucent fatty mass—thence called butter of antimony. It melts at 72° C., and boils at about 200°: fumes slightly in the air, and is very corrosive. When thrown into water, it is decomposed into hydrochloric acid and trioxide of antimony, which however remains united with a portion of the chloride, forming a white powder called *powder of algaroth*. The same decomposition takes place on adding water to the solution of the trichloride in strong hydrochloric acid. The precipitate is redissolved by excess of hydrochloric acid, and the solution, which contains hydrated trichloride of antimony, is the most convenient that can be used for exhibiting the reactions of antimony. The addition of tartaric acid to this solution, prevents its decomposition by water.

The anhydrous trichloride combines with ammonia, forming the compound $NH^3.SbCl^3$, and forms crystalline compounds with the chlorides of the alkali-metals.

PENTACHLORIDE OF ANTIMONY, $SbCl^5$, is formed, with brilliant combustion, when finely powdered antimony is thrown into chlorine gas. It may be prepared by passing dry chlorine over pulverised antimony, gently heated in a tubulated retort provided with a receiver, or over the trichloride. Hofmann (Chem. Soc. Qu. J. xiii. 65) introduces metallic antimony coarsely powdered into a combustion-tube five or six feet long, rising at an angle of 10° or 15°, one end being fitted into a tubulature of a two-necked glass globe, the other neck of which is connected with a tube supplying dry chlorine. Combination takes place in the tube, and the products flow backwards into the globe, whilst the long layer of antimony prevents the escape of any chlorine.—Pentachloride of antimony is a colourless or yellowish, very volatile liquid, which emits suffocating vapours. *Water* first converts it into a crystalline hydrate and then decomposes it, forming hydrochloric and antimonic acids. It absorbs *ammonia* and *phosphoretted hydrogen*, forming solid red-brown compounds. It absorbs *olefiant gas*, C^2H^4, as readily as chlorine, and forms Dutch liquid. By passing dry olefiant gas and dry chlorine simultaneously through boiling pentachloride of antimony, in a retort connected with an inverted condenser, large quantities of Dutch liquid may be easily obtained. The pentachloride here acts as a carrier of free chlorine, a purpose for which it may often be advantageously used (Hofmann, *loc. cit.*) It likewise absorbs *hydrosulphuric acid gas*, at ordinary temperatures, forming a white crystalline chlorosulphide of antimony, $SbCl^3S$, analogous to chlorosulphide of phosphorus, PCl^3S.—With *bisulphide of carbon*, the latter being in excess, it yields tetrachloride of carbon, trichloride of antimony, and free sulphur:

$$CS^2 + 2SbCl^5 = CCl^4 + 2SbCl^3 + S^2.$$

The mixture becomes very hot, and on cooling deposits crystals of trichloride of antimony, mixed with sulphur-crystals, the tetrachloride of carbon remaining in the liquid state (Hofmann, *loc. cit.*). The pentachloride combines with *hydrocyanic acid*, forming a white, crystalline, volatile compound, containing $SbCl^5.3HCy$: also with *chloride of cyanogen*.—A white pulverulent substance containing $2SbCl^5.3SCl^2$, is obtained by heating pentasulphide of antimony in dry chlorine gas; it is decomposed at 300° C. into chloride of sulphur, trichloride of antimony, and free chlorine.

ANTIMONY, DETECTION AND ESTIMATION OF:

1. *Blowpipe Reactions.*—Solid compounds of antimony fused upon charcoal, with dry carbonate of sodium or cyanide of potassium, yield a brittle globule of antimony, a thick white fume being at the same time given off, and the charcoal covered to some distance around with a white deposit of oxide. If the heat be continued for some time, the globule will be completely dissipated. The reduction with cyanide of potassium may be performed in a porcelain crucible without charcoal.

The antimony globule is converted by nitric acid into a white oxide, soluble in a boiling solution of cream of tartar. It is insoluble in pure hydrochloric acid, but dissolves easily on addition of a small quantity of nitric acid, forming a solution of the trichloride, which is decomposed by water, forming a white precipitate, soluble in excess of hydrochloric or tartaric acid. If tartaric acid be previously added, water produces no precipitate.

he acid solution of the trichloride gives with *hydrosul-*
recipitate of the trisulphide, easily soluble in sulphide of
l by acids.—With *potash*, it forms a white precipitate of
s excess of the reagent.—*Ammonia* forms the same pre-
Carbonate of potassium or *sodium* also gives a white
ich dissolves in excess, especially of the potassium-salt,
If, however, the solution contains *tartaric acid*, the pre-
olves easily in excess of the alkali,—ammonia forms but
after long standing,—and the precipitates formed by the
uble in excess of those reagents. These last mentioned
y a solution of tartar-emetic (tartrate of antimony and
this salt is decomposed by the stronger acids, yielding a
f acid tartrate of potassium, mixed with the oxide or a
solutions of barium, strontium, calcium, lead, and silver,
nsisting of tartar-emetic, the potassium of which is re

gold, added to a solution of trichloride of antimony, or
a yellow precipitate of metallic gold, antimonic acid being
ed in the form of a white powder, unless the solution
lrochloric acid :

$$O^3 + 6H^2O = 4Au + 12ClH + 3Sb^2O^5.$$

nary temperatures, but is accelerated by heating. In a
monious acid), in potash, trichloride of gold produces a
s a very delicate reaction for antimonious acid. *Nitrate*
on of trichloride of antimony, a white precipitate, from
t chloride of silver, leaving oxide of antimony undis-
monious acid in potash, nitrate of silver produces a deep
n ammonia. In a solution of tartar-emetic, nitrate of
te, perfectly soluble in ammonia: but if the solution be
of potash, nitrate of silver produces a black precipitate

timony from its solutions, in the form of a black powder.
e form of a brilliant metallic film, which may be dissolved
nate of potassium, yielding a solution which will give the
with hydrosulphuric acid. (Odling, Guy's Hospital

guished from antimonious acid by the different colour of
s with *hydrosulphuric acid* (p. 328); but better by its
ld and nitrate of silver. *Trichloride of gold* produces no
monic acid, not even when they contain excess of potash.
solution of antimonate of potassium, forms a white preci-
, perfectly soluble in ammonia: if the solution contains
te is brown from admixed oxide of silver, but even then
monia. The slightest trace of antimonious acid present
insoluble in ammonia. If a small quantity of an oxide
be rubbed up with water to a milky liquid in a porcelain
tened with *ammonio-nitrate of silver*, a black spot will
ony is present, either in the free state or combined with
ntimonic acid is present, no blackening will take place.
n (Bunsen, Ann. Ch. Pharm. cvi. 1).—Antimonic acid
rom the trioxide by its behaviour with *hydriodic acid*,
hydrochloric acid to which iodide of potassium is added,
id, containing tri-iodide of antimony, without separation
l or antimonate of antimony, forms under the same cir-
l dark brown by free iodine :

$$^3 + 6HI = 2SbI^3 + 3H^2O$$
$$^5 + 10HI = 2SbI^3 + 5H^2O + 4I.$$

cid is considerable, the liquid gives off violet vapours on
not exceed a few hundredths of a milligramme, the free
detected by shaking it up with a few drops of bisulphide
s a violet or amethyst colour when it rises to the surface.
the hydrochloric acid do not contain free chlorine, and
be free from iodate. (Bunsen.)

When the presence of antimony is suspected in liquids containing considerable quantities of organic matter, as in cases of supposed poisoning by tartar-emetic or other antimonial preparations, it is best to destroy the organic matter by oxidation with hypochlorous acid. If the matter to be examined is solid, it should be cut into small pieces; if a large quantity of liquid is present, it must be brought by evaporation to a convenient bulk. It is then mixed with strong hydrochloric acid, a gentle heat applied, and chlorate of potassium added by small portions, till the liquid acquires a light yellow colour. It is then heated till the odour of chlorine is no longer perceptible, and afterwards left to cool and filtered. From the clear liquid thus obtained, the antimony may be precipitated by hydrosulphuric acid, or by metallic copper, and the precipitates treated in the manner already described; or the liquid may be introduced into a Marsh's apparatus (see ARSENIC), with zinc and dilute sulphuric acid, and the antimony reduced, either in the escape-tube by the heat of a lamp, or on a porcelain plate held in the flame. The metallic deposit thus obtained may be dissolved in aqua-regia, and the solution treated with hydrosulphuric acid, which will produce the characteristic brick-red precipitate. Another method of testing the deposit is to moisten it with nitric acid, of specific gravity 1·42, then heat the vessel over a lamp, and blow over the surface so as to cause the acid to evaporate without boiling. The white deposit then remaining consists chiefly or wholly of trioxide of antimony, which will produce a deep black spot with ammonio-nitrate of silver. A deposit of metallic arsenic, treated in the same way, gives with ammonio-nitrate of silver, either a yellow precipitate of arsenite, or a red-brown precipitate of arsenate of silver, according to the degree of oxidation produced by the nitric acid. (Bunsen.)

3. *Quantitative Estimation.*—1. Antimony may be accurately estimated in the form of tetroxide or antimonate of antimony, SbO^2, that oxide being neither volatile nor decomposible at a red heat. The antimony being precipitated from solution by hydrosulphuric acid, the precipitate is washed and dried, then placed, together with the filter, in a porcelain basin covered with a funnel, and fuming nitric acid poured upon it. A violent action then takes place, the antimony and the greater part of the sulphur being immediately oxidised: the oxidation of the sulphur may be completed by heating the vessel over a water-bath. The resulting white mass, consisting of antimonic acid mixed with sulphuric acid, is converted by ignition into pure antimonate of antimony, containing 79·22 per cent. of the metal. The oxidation of the sulphide of antimony cannot be conveniently effected by nitric acid of ordinary strength (specific gravity 1·42), because that liquid boils at a temperature 10° C. above the melting point of sulphur, and consequently the sulphur separated at the commencement of the action collects in melted globules, which are extremely difficult to oxidise, and if left in the mass during the subsequent ignition, would reconvert a portion of the oxide of antimony into sulphide. Fuming nitric acid, on the contrary, boils below the melting point of sulphur, and the sulphur separated by its action takes the form of a fine powder, which is easily oxidised at a gentle heat. If the sulphide of antimony is mixed with a large quantity of free sulphur (which is often the case when it has been dissolved in an alkaline sulphide and reprecipitated by an acid), it is best to remove the free sulphur by washing the precipitate with bisulphide of carbon.

The oxidation of the sulphide of antimony may also be effected by igniting it with mercuric oxide (prepared by precipitating a hot solution of mercuric chloride with excess of caustic potash). When these substances are heated together in equivalent proportions, a violent explosion takes place; but if the sulphide of antimony be mixed with between thirty and fifty times its weight of mercuric oxide, the oxidation takes place quietly. The mixture is heated in a porcelain crucible, gently, so long as mercurial vapours go off, afterwards more strongly, and at last very strongly, to expel the last traces of mercury. Antimonate of antimony then remains in the form of a soft white powder. As mercuric oxide, even when prepared with the greatest care, always leaves a small residue when ignited, the amount of this residue must be determined once for all, and the proportionate amount deducted from the weight of the antimonate of antimony. As, however, this residue never exceeds a few thousandths of the whole, it is not necessary to weigh the oxide of mercury with great exactness. In this process, it is necessary, if the sulphide of antimony contains a large excess of free sulphur, to remove that substance by washing with bisulphide of carbon, before proceeding to the ignition; because free sulphur, even when ignited with a large excess of mercuric oxide, produces explosions which might occasion loss. The method just described has been lately introduced by Bunsen (Ann. Ch. Pharm. cvi. 3). It is quite exact, provided due attention be paid to the precautions above indicated.

2. The precipitated sulphide of antimony is collected on a weighed filter, dried in an oil-bath, at about 120° C., and then weighed. A known portion of it is then either decomposed by ignition in an atmosphere of hydrogen, whereby the sulphur is expelled

ric acid, and metallic antimony remains: or a weighed
idised by means of hydrochloric acid and chlorate of potas-
nued till the greater part of the sulphur is converted into
inder collected at the bottom of the liquid in a melted
diluted with water containing tartaric acid, to prevent
salt of antimony, and decanted; the globule of sulphur
e quantity of sulphur in solution estimated as sulphate of
quantity thus found being added to the weight of the
sulphur in the precipitated sulphide of antimony being
ntimony is easily calculated. Antimony cannot be accu-
veighing the precipitated sulphide, because the precipitate
sulphur, and sometimes pentasulphide of antimony in

timonic acids exist together in solution, the total quantity
ed by treating one portion of the liquid as above described,
antimonious acid determined in another portion by means
of precipitated gold corresponding to 3 at. of antimony

ony.—Berzelius (Schw. J. xxii. 69) determined the
d from a given weight of the metal by oxidation with
l, for the atomic weight of antimony, the number 129·03.
e recently been followed by Dexter (Pogg. Ann. c. 579),
per 122·33: but even this number was till lately regarded
supposed to arise from incomplete oxidation and the con-
e with the tetroxide.

xcviii. 293) determined the atomic weight of antimony
ative trisulphide by hydrogen. Stibnite from Arnsberg,
ulphide of antimony mixed with only a small quantity of
vas decomposed by ignition in a stream of hydrogen, and
ed, the escaping gas being passed into aqueous ammonia
antimony that volatilised, and this quantity being after-
chloric acid, oxidised by fuming nitric acid, and weighed
l not exceed 1 or 2 milligrammes). Corrections were also
mineral and for the small amount of sulphide which
volatilised; for which purpose the residue in the reduc-
n digested in aqua-regia, the residual quartz again weighed,
determined by precipitation as sulphate of barium, and
he residue thence determined (about 0·4 per cent.). After
e composition of the trisulphide (Sb^2S^3) was found to be
)0, whence, the atomic weight of sulphur being 32, that of

$$b = \frac{71·48}{28·52} \times 48 = 120·30.$$

th former determinations by H. Rose, and also with that
n. xcviii. 455), from the analysis of trichloride of anti-
by decomposing trichloride of antimony with a standard
e atomic weight of antimony the number 122, which agrees
by Dexter. (Ann. Ch. Pharm. cxiii. 29.)

)res.—To estimate the amount of antimony in the native
ly roasted, and then fused at a moderate heat with 1 to
ut 25 per cent. of borax, the whole being covered with a
quantity of metal which can be thus extracted from the
4 to 64 per cent, the calculated quantity being 71·5 per
sed with iron filings (about 42 pts. iron to 100 of sulphide),
weight of black flux, and about 25 per cent. of borax, the
thick layer of common salt. This process yields 66 to 68
e sulphide.

of sulphide of antimony in a sample of the crude ore, the
e of a walnut, is heated in a hessian crucible perforated at
ther crucible placed below the grate, and surrounded with
l. Care must be taken to avoid applying too much heat.
ked by hydrochloric acid, the amount of sulphide may be
ghed portion of the ore with that acid and weighing the
nde, iii. 26.)

imony from other metals.—From the metals of the
e ANALYSIS, p. 213) antimony is separated by precipitation

with hydrosulphuric acid; from those of the first group, whose sulphides are insolub' in alkaline sulphides, it is separated by precipitating with hydrosulphuric acid an digesting the precipitate in sulphide of ammonium. The sulphide of antimony the dissolves, the other metals remaining undissolved; and on mixing the filtrate wit excess of hydrochloric or acetic acid, the sulphide of antimony is reprecipitated. Whe hydrochloric acid is used, care must be taken to keep the liquid dilute and not allow i to get hot, otherwise some of the antimony may be redissolved.

When antimony is combined with other metals in the form of an alloy, it may ofte be separated by treating the alloy with moderately strong nitric acid, which dissolve the other metals, leaving the antimony in the form of antimonic acid, which may the be converted into antimonate of antimony by ignition. This method, however, is no rigidly exact, because the nitric acid dissolves a small portion of the antimony; but is near enough for commercial purposes. It is of course not applicable to the separa tion of antimony from tin, gold, or platinum.

The separation of antimony from *tin* may be effected by immersing in the solution piece of pure tin, which precipitates the antimony in the form of a black powder. T render the separation complete, a gentle heat must be applied, and the solution shoul contain an excess of acid. The antimony is collected on a weighed filter, dried at gentle heat, and weighed. If the sum of the weights of the two metals in the solutio is previously known, the amount of tin is at once determined by difference; if not, th metals must be precipitated together by zinc from a known quantity of the solution, a the antimony precipitated by tin from another portion.—Another method of separa tion given by Levol (Ann. Ch. Phys. [3] xiii. 125) is, to precipitate the two metals b zinc, and treat the precipitate with strong hydrochloric acid, without previously decanti the solution of chloride of zinc. The tin then dissolves, while the antimony remai undissolved, the presence of the chloride of zinc diminishing its tendency to dissol in the acid. The tin may be afterwards precipitated by hydrosulphuric acid, and th sulphide converted into stannic oxide by treating it with strong nitric acid.

For the separation of antimony from *arsenic*, *gold*, and *platinum*, see those metal From *selenium* and *tellurium*, antimony is separated in the same manner as arsenic (*q.*

ANTIMONY, FLUORIDE OF. SbF^3.—Obtained by dissolving the trioxide hydrofluoric acid. It forms colourless crystals, which dissolve completely in wat without decomposition.

ANTIMONY, GLASS OF. See ANTIMONY, OXYSULPHIDE OF.

ANTIMONY, HYDRIDE OF, or **ANTIMONIDE OF HYDROGE** generally called *Antimonetted* or *Antimoniuretted hydrogen* SbH^3.—When an ant mony-compound, tartar-emetic for example, is introduced into an apparatus in whic hydrogen is generated by the action of zinc or dilute sulphuric acid, the flame pr duced by the combustion of the gas at the orifice of the jet, acquires a bluish tin from admixture of antimonide of hydrogen. This compound may be obtained in state of greater purity by dissolving an alloy of 2 pts. of zinc and 1 pt. of antimo in hydrochloric or dilute sulphuric acid. It is always, however, more or less co taminated with free hydrogen.

It is a colourless gas, and when free from arsenic, quite inodorous; insoluble water and in alkaline liquids. When it is passed into hot concentrated nitric acid, white powder is deposited, consisting of antimonic acid. When passed into a solutio of nitrate of silver or chloride of mercury, it forms a black precipitate, containing t whole of the silver or mercury. The silver-precipitate has been found to be SbAg and is formed by simple substitution of silver for hydrogen. Hence the antimoni of hydrogen is inferred to be SbH^3, analogous to ammonia, and to arsenide and pho phide of hydrogen, AsH^3 and PH^3.

When antimonide of hydrogen is passed through a tube of hard glass and strong heated by the flame of a lamp, it is decomposed, and a mirror of metallic antimony deposited on the tube. If a funnel be held over the flame of the gas, a deposit trioxide of antimony is formed on its inner surface. A cold porcelain dish held in th middle of the flame, becomes covered with spots of metallic antimony, which are dark in colour than those formed in a similar manner by arsenic, and are further di tinguished from the latter by not dissolving in hypochlorite of sodium. The antimo deposit dissolves easily in aqua-regia and in permanganate of potassium, and th solution thus formed exhibits the characteristic reactions of antimony with hydr sulphuric acid, &c. (p. 319).

There are several compounds of antimony with alcohol-radicles, analogous antimonetted hydrogen, viz. *stibtrimethyl*, $Sb(CH^3)^3$, *stibtriethyl*, $Sb(C^2H^5)^3$, and *sti triamyl*, $Sb(C^5H^{11})^3$.

ANTIMONY, IODIDE OF. SbI^3.—Prepared like the bromide. It is a da red body, decomposed by water, forming an *oxyiodide*. The *sulphiodide*, $Sb^2I^2S^3$,

ate, by heating an intimate mixture of iodine and the
t is decomposed by water, yielding hydriodic acid and an

OF. See p. 311; for the valuation, p. 321.

ES OF. Antimony forms with oxygen three definite com-

nious oxide	Sb^2O^3
onoso-antimonic oxide . . .	Sb^2O^4
onic oxide	Sb^2O^5

a compound of the other two, $Sb^2O^3.Sb^2O^5 = 2Sb^2O^4$. A
id to be produced, as a grey film, when antimony is used as
trolysis of water. It appears, however, to be merely a mix-
trioxide, for, when treated with hydrochloric acid, it yields
l a residue of antimony. (Berzelius.)

ONY, or ANTIMONIOUS OXIDE, Sb^2O^3, occurs, though
al (*Valentinite*, *White Antimony*, *Antimony-bloom*, *Weiss-*
white crystals belonging to the trimetric system; specific
·5—3. It occurs in veins of primary rocks at Przibram in
Saxony, and at Malaczka in Hungary. It is found also
z. as *Senarmontite*, a mineral from the Gued Hamimim
nstantine, Algeria: it is therefore dimorphous. This oxide
urns in the air, and may be prepared by heating antimony
sed with its cover: it is then deposited on the sides of the
melted metal, in shining prismatic crystals, known by the
, *flores antimonii argentei*. But the easiest mode of obtain-
hide with strong hydrochloric acid as long as hydrosulphuric
and pour the resulting solution of the trichloride into a
ate of sodium. A crystalline powder is then deposited,
aham) of the anhydrous trioxide:

$$+ 3Na^2CO^3 = Sb^2O^3 + 6NaCl + 3CO^2.$$

(Cours de Chimie, iii. 239) that the oxide thus obtained is
.H^2O or $SbHO^2$. The trioxide is likewise obtained, though
antimonic acid, by treating metallic antimony with nitric

the native trioxide of antimony is dimorphous. The
pid oxidation of the metal belong to the trimetric or right
nes, however, when the oxide is sublimed at a comparatively
few ounces of antimony are heated till the metal begins
ool slowly, the prismatic crystals are mixed with regular
o Mitscherlich (Ann. Ch. Phys. [2] xxxiii. 394) the
n regular octahedrons from a solution in boiling soda. In
omorphous with one of the forms of trioxide of arsenic
bodies are therefore isodimorphous. Antimonious oxide is
ordinary temperatures, but turns yellow when heated. It
sublimes when raised to a higher temperature in a close
he air, it is partly converted into antimonic oxide. It is
ne, but is reduced to the metallic state when heated with
ssium.

issolves sparingly in *water*, more freely in strong *hydro-*
lution is quite clear, provided the oxide is free from
dered turbid by dilution with water. It dissolves when
ic acid, and very easily in a solution of *acid tartrate of*
forming the *tartrate of antimony and potassium*, or *tartar-*
ARTRATES.)

tric acid of ordinary strength; but dissolves in cold fuming
ion which deposits pearly scales of a nitrate, $N^2O^5.2Sb^2O^3$
also in *fuming sulphuric acid*, the solution depositing
containing $3SO^3.Sb^2O^3$. It does not absorb *carbonic acid;*
imony is known to exist.

ts as a feeble acid, forming salts called antimonites.
issolves easily in *alkalis*, but the resulting compounds are
osed by mere evaporation. The solutions give with nitrate
onia, a black precipitate insoluble in free ammonia. They
, precipitating the metal. More stable salts, the anti-

monoso-antimonates, are formed by the union of the antimonites with antimon
(*vid. inf.*). The trioxide fused with caustic alkalis or their carbonates is conve
into antimonic acid, which unites with the alkali. (**Frémy**.)

Tetroxide of Antimony, or **Antimonoso-antimonic oxide**, someti
called *Antimonious acid*, Sb^2O^4.—This oxide is found native, as *Cervantite* or *Antim*
ochre, forming acicular crystallisations, or massive, or as a crust or powder.
yellow, or nearly white, of a greasy, bright or earthy lustre, and specific gr
4·084. It is found at Pereta, in Tuscany (**Dana**, iii. 141). The same oxide is
duced by the action of heat upon antimonic oxide (Sb^2O^5), by roasting the trioxid
trisulphide, or by treating pulverised antimony with excess of nitric acid. As
prepared, it is white, infusible, and unalterable by heat; slightly soluble in w
more soluble in hydrochloric acid. It is easily resolved into antimonious and
monic oxides. On boiling it with acid tartrate of potassium (cream of tartar)
monious oxide dissolves, and antimonic oxide is left behind; and when a solution o
tetroxide in hydrochloric acid is gradually dropped into a large quantity of wat
precipitate of antimonious oxide is first produced, while antimonic acid remain
solution. From these and similar reactions, it has been inferred that the tetroxide
compound of the trioxide and pentoxide, or an antimonate of antimony (Sb^2O
$Sb^2O^5 = 2Sb^2O^4$). On the other hand, it is sometimes regarded as a distinct o
because it dissolves in alkalis, forming salts (often called *antimonites*), which
be obtained in the solid state. By fusing the tetroxide with hydrate or carbona
potassium, exhausting with cold water, treating the residue with boiling water,
evaporating to dryness, a yellow, uncrystalline, saline mass is obtained, compos
$K^2O.Sb^2O^4$, and by mixing the solution of this salt with a small quantity of hy
chloric acid, a more acid salt, $K^2O.2Sb^2O^4$ is precipitated. By treating the
solution with a large quantity of acid, a precipitate is formed, consisting of
hydrated tetroxide, $H^2O.Sb^2O^4$. It is, however, more in accordance with the reac
above-mentioned, to regard these salts as **antimonoso-antimonates**, that is to
as compounds of *antimonates* (containing Sb^2O^5) with antimonites (containing Sb
thus the salt, $K^2O.Sb^2O^4$, may be regarded as $(K^2O.Sb^2O^3) + (K^2O.Sb^2O^5)$, or KS
$KSbO^3$.

The antimonoso-antimonates of the earth-metals and heavy metals are insolub
water, and may be obtained by precipitation. Two of them are known as na
minerals, viz.—1. *Romeine*, or (so-called) *Antimonite of calcium*, found at St. M
in Piedmont, in groups of minute square-based octahedrons, of hyacinth-re
honey-yellow colour; specific gravity 4·714 (in powder 4·675), hard enough to sc
glass. It contains 62·18 per cent. antimony, 15·82 oxygen, 16·29 lime, 1·31 iron,
protoxide of manganese, and 2·86 silica. The formula, $3Ca^2O.2Sb^2O^4$, requires
per cent., Sb, 22·7 O, and 15·4 Ca (**Dana**, ii. 410).—2. *Ammiolite*, or (so-called)
monite of mercury, occurs, mixed with clay and hydrated sesquioxide of iron, i
quicksilver mines in Chili, and at Silberg, near Olpe in Westphalia. It is a
powder, containing, according to **Domeyko** (Ann. Min. [4] vi. 183), 12·5 per
Sb^2O^4, 14·0 HgO, 22·3 Fe^2O^3, 26·5 SiO^2, and 24·7 water (and loss). Probably o
mixture. (**Dana**, ii. 142.)

Pentoxide of Antimony, Antimonic Oxide or Anhydride, S
In the hydrated state: **Antimonic Acid**.—This compound is obtained as a hyd
—1. By treating antimony with nitric acid, or with aqua regia containing exc
nitric acid.—2. By precipitating a solution of antimonate of potassium with an
—3. By decomposing pentachloride of antimony with water.

The hydrated oxide obtained by either of these methods gives off its water
heat below redness, and yields the pentoxide or anhydrous antimonic acid,
yellowish powder. The same body is obtained by heating pulverised antimony
mercuric oxide till the green antimonate of mercury at first produced is decom
and all the mercury driven off. It is tasteless, insoluble in water and in acids,
has a specific gravity of 6·6 (**Boullay**). At a red heat, it gives off oxygen,
converted into the tetroxide. It is dissolved by boiling potash-ley, and when
with carbonate of potassium expels carbonic anhydride and forms a salt, from
acids separate hydrated antimonic acid.

The hydrated oxides or acids obtained by the three methods above given, are
means identical. That obtained by the first and second method is monobasic, a
cording to **Berzelius**, contains $Sb^2O^5.H^2O$ or $SbHO^3$; according to **Frémy**, $Sb^2O^5.5$
or SbH^5O^5, when air-dried at mean temperature; but the acid obtained by the act
water on pentachloride of phosphorus is dibasic, and contains, according to **Fr**
$Sb^2O^5.4H^2O$. The monobasic acid is called *Antimonic acid*; the dibasic acid, *Me*
monic acid. These acids are further distinguished by the following characters.
monic acid is a soft white powder, sparingly soluble in water, reddens litmus,
dissolved, even in the cold, by strong hydrochloric acid and by potash-ley. The h

a small quantity of water, yields after a while, a precipi-
if diluted with a large quantity of water, it remains clear.
it in the cold. It is converted into metantimonic acid by
of hydrate of potassium.—Metantimonic acid dissolves in
imonic acid, and is dissolved by ammonia, after a while,
ires. It likewise dissolves completely in a large quantity
ed therefrom by acids. It is very unstable, and easily
, even in water.

NTIMONATES.—Antimonic acid forms neutral or normal
^{5} or $MSbO^3$, and acid salts containing $M^2O.2Sb^2O^5$, or
nic acid, which is dibasic, forms normal salts containing
d acid salts containing $2M^2O.2Sb^2O^5$, or $M^2O.Sb^2O^5$, so that
isomeric or polymeric with the neutral antimonates.* An
changes into a neutral antimonate (**Frémy**, Ann. Ch.
xii. 404).—**Heffter** (Pogg. Ann. lxxxvi. 411) analysed a
ch, calculating from the old atomic weight of antimony
in 12 at. Sb^2O^5 to 13 at. of a base M^2O; but on recalculat-
w atomic weight ($Sb = 120{\cdot}3$), it is found that they agree
$^2O.Sb^2O^5$.

ammonium, potassium, and sodium, are crystalline; the
ses are gelatinous and uncrystallisable. The soluble acid
stalline precipitate with sodium-salts; the soluble antimo-
precipitate.

etantimonates of the alkali-metals are the only ones that
All the rest are insoluble or sparingly soluble, and may
.

nium.—On adding the solution of an aluminium-salt to
tassium, the whole of the alumina is precipitated in com-
cid, in white flocks, somewhat soluble in excess of the

nium, $(NH^4)^2O.Sb^2O^5 + 2H^2O$, or $(NH^4)SbO^3 + H^2O$, sepa-
m a solution of antimonic or metantimonic acid in warm
al *metantimonate of ammonium*, $2(NH^4)^2O.Sb^2O^5$, is ob-
ting metantimonic acid with *cold* aqueous ammonia; it is
solid state. The solution mixed with a drop or two of
ine salt, which is the *acid metantimonate of ammonium*,
This salt is soluble in water, and the solution precipitates
unstable, being converted, with loss of water, slowly at
immediately at the boiling heat, into the insoluble neutral
s isomeric.

ony, $Sb^2O^3.Sb^2O^5$.—The tetroxide of antimony is sometimes
his manner (p. 317).

um, $Ba''O.Sb^2O^5$, or $Ba''Sb^2O^6$, is obtained by double decom-
ecipitate which gradually becomes crystalline; it dissolves
of barium.

um, $Ca''O.Sb^2O^5$, is a crystalline precipitate, which adheres
essel, like carbonate of calcium.

lt, $Co''O.Sb^2O^5$.—Reddish crystalline precipitate, which,
er, turns violet, and then black; when heated to redness, it
on cooling appears nearly white.—By mixing a solution of
ot solution of antimonate of sodium, **Heffter** (*loc. cit.*)
coloured precipitate, containing $Co''O.Sb^2O^5 + 7H^2O$, and
nding for some days, deposited six-sided prisms containing

er, $Cu''O.Sb^2O^5$, or $Cu''Sb^2O^6$, is a greenish crystalline powder,
ff 19½ per cent. water, and turns black. At a red heat, it
rns white, and is afterwards unattackable by acids or alkalis
efore the blowpipe, it is reduced to antimonide of copper.

.—The *ferrous* salt is a white powder which becomes yel-
by ignition, and is sparingly soluble in water. The *ferric*

$Pb''O.Sb^2O^5$, or $Pb''Sb^2O$, is obtained as a yellow anhydrous
of antimony with oxide of lead, or as a white hydrate by
gives off its water when heated, and turns yellow.

---

neutral and acid antimonates are $MO.SbO^5$ and $MO.2SbO^5$, and of the
$2MO.SbO^5$ respectively.

A basic antimonate of lead, known by the name of *Naples Yellow*, is much used in oil-painting. It is obtained of the finest colour by mixing 2 pts. of chemically pure nitrate of lead with 1 pt. of the purest tartar-emetic and 4 pts. of common salt purified by repeated crystallisation, exposing the mixture for two hours to a heat just sufficient to fuse the chloride of sodium, and dissolving out the chloride of sodium with water; if the temperature has not been allowed to rise too high, the Naples yellow is then obtained in the form of a fine powder. — The same pigment is likewise obtained, but generally of a less brilliant colour, by fusing equal parts of antimony and lead with 3 pts. of nitre and 6 pts. of common salt.

Another basic antimonate of lead, $3Pb''O.Sb^2O^5 + 4H^2O$, occurs native at Nertschinsk in Siberia, forming the mineral *Bleinierite*. It is amorphous, reniform, spheroïdal; also earthy or incrusting; sometimes with curved lamellar structure, specific gravity 3·933 (Karsten); 4·6—4·76 (Hermann). Lustre resinous, dull, or earthy. Colour grey, brownish, or yellowish. Opaque. Streak, greyish or yellowish. It is perhaps a mechanical mixture of lead and antimony ochres, and appears to result from the decomposition of other ores of antimony. (Hermann, J. pr. Chem. xxxiv. 179.)

Antimonate of Lithium. — Obtained by mixing a concentrated solution of chloride of lithium with antimonate of potassium, in flocks which soon become crystalline. It dissolves easily in hot water, and separates in grains on cooling. In dilute solutions, no precipitate is obtained.

Antimonate of Magnesium, $Mg''O.Sb^2O^5 + 12H^2O$. — Separates by double decomposition from boiling solutions, in colourless shining hard crystals, which are isomorphous with the corresponding cobalt-salt, give off 8 per cent. water at 100° C., 10 per cent. at 200°, and 11 per cent. at 300°. (Heffter.)

Antimonate of Manganese. — White, altered by exposure to the air, sparingly soluble in water, somewhat more soluble in excess of the manganous salt. At a red heat, it becomes unattackable by acids, but does not glow.

Mercuric Antimonate, $Hg''O.Sb^2O^5$, or $Hg''(SbO^3)^2$, is obtained by double decomposition as an orange-yellow precipitate. There is also an olive-green mercuric antimonate obtained by heating to low redness a mixture of 1 pt. powdered antimony, and 6 or 8 pts. mercuric oxide. At a stronger heat, this salt gives off oxygen and mercury, and leaves antimonic oxide. It is but little attacked by acids; but boiling hydrochloric acid dissolves a small quantity of it, and ammonia added to the solution throws down a light green powder.

Antimonate of Nickel. — Sulphate of nickel mixed with a boiling solution of antimonate of potassium, immediately forms a light green flocculent precipitate containing $Ni''O.Sb^2O^5 + 6H^2O$, and the mother-liquor, after a few days, yields crystals of darker colours isomorphous with the magnesium-salt and analogous to it in constitution.

Antimonates of Potassium. — The neutral salt, $K^2O.Sb^2O^5 + 5H^2O$, is obtained by fusing 1 pt. of antimony with 4 pts. of nitre, digesting the fused mass in tepid water to remove nitrate and nitrite of potassium, and boiling the residue for an hour or two with water. The white insoluble mass of anhydrous antimonate is thereby transformed into a hydrate containing 5 at. water, which is soluble. The solution, when evaporated, leaves this hydrate in the form of a gummy uncrystallisable mass, which gives off 2 at. of water at 160° C., and the whole at a higher temperature. According to Heffter the anhydrous neutral antimonate is partly decomposed by prolonged boiling with water, an acid salt $2K^2O.Sb^2O^5$ remaining undissolved, and the liquid filtered therefrom yielding by evaporation the neutral salt with 7 at. water: $K^2O.Sb^2O^5 + 7H^2O$.

Acid Antimonate of Potassium is obtained by passing carbonic acid gas through a solution of the neutral antimonate. It is white, crystalline, perfectly insoluble in water, and is converted into the neutral salt when heated with excess of potash. This salt is the *antimonium diaphoreticum lavatum* of the pharmacopœias. (Frémy.) According to Heffter, the salt thus obtained is $2K^2O.3Sb^2O^5 + 10H^2O$.

Neutral Metantimonate of Potassium is prepared by fusing antimonic oxide or neutral antimonate of potassium with a large excess of potash. The fused mass dissolves in a small quantity of water, and the solution evaporated in vacuo yields crystals of the neutral metantimonate. This salt dissolves freely and without decomposition in warm water containing excess of potash; but cold water or alcohol decomposes it into potash and the acid matantimonate. Hence the aqueous solution of this salt gives a precipitate, after a while, with salts of soda. (Frémy.)

Acid Metantimonate of Potassium, $K^2O.Sb^2O^5 + 7H^2O$, sometimes called *granular antimonate of potassium.*—This salt is used as a test for soda. To obtain it, the neutral antimonate is first prepared and dissolved in the manner above described; the

te any acid antimonate that may remain undissolved, then
ilver vessel; and hydrate of potassium is added in lumps to
o metantimonate. The evaporation is then continued till
lise, which is ascertained by taking out a drop now and
the liquid is then left to cool. A crystalline mass is thus
tral and acid metantimonate of potassium; the alkaline
l the salt dried upon filtering paper or unglazed porcelain
also be prepared by treating trichloride of antimony with
nt to redissolve the precipitate first formed, and adding
till the solution acquires a faint rose colour. The liquid,
elds crystals of the granular metantimonate (Reynoso).
le in cold water, but dissolves readily in water, between
led with water for a few minutes, or kept in contact with
nverted into the neutral antimonate. It must therefore be
, and dissolved just before it is required for use. A small
ed with about twice its weight of cold water, to remove
vert any neutral metantimonate into the acid salt; the
remaining salt is rapidly washed three or four times with
tact with water for a few minutes, and the liquid is filtered.
nus obtained a small quantity of any sodium-salt, a crystal-
onsisting of *acid metantimonate of sodium* (*vid. inf.*).

m is obtained in tabular aggregates of small crystals, when
rom washing a deflagrated mixture of antimony and nitre,
t. This salt has, according to Frémy, the composition
salt of the same constitution is obtained, according to
ons, by boiling golden sulphide of antimony with caustic
eous extract. It is nearly insoluble in cold water, soluble
water. It gives off 2 at. water at 200° C., 2 at. more at
heat.

Sodium, $Na^2O.Sb^2O^5 + 7H^2O$, or $2NaHO.Sb^2O^5 + 6H^2O$.—
solution of acid metantimonate of potassium, free from excess
olution of a sodium-salt. If the solution is not very dilute
t at first, but soon becomes crystalline. It is produced
ntaining not less than 1 pt. of sodium-salt in 300 pts. of
utions, the precipitation is gradual, the metantimonate of
rystals on the sides of this vessel, the effect being apparent
solutions containing not more that $\frac{1}{1000}$ pt. of sodium-salt.
ated and rendered more complete by adding a little alcohol.
i retards it. The solution of sodium to be tested in this
salts of lithium, ammonium, and the earth-metals, all of
ertain extent, yield precipitates of similar character. Acid
ives off 6 at. of water at 100°C., the seventh at about 300°.

tium.—Amorphous precipitate containing $Sr''O.Sb^2O^5 +$

$Zn''O.Sb^2O^5$.—Crystalline precipitate somewhat soluble in
hen heated, it gives off water and turns yellow, but without
al before the blowpipe it does not fuse; neither is it
f alkali.

HLORIDE OF. *Basic Chloride of Antimony, Powder
hi s. angelicus, Mercurius Vitæ*, &c.—A compound formed
trichloride of antimony. It was formerly much used in
serves chiefly for the preparation of pure antimonious
The best way of preparing it is to boil commercial sulphide
r with strong hydrochloric acid, till the liquid is saturated,
ping all the while; leave the solution to cool; add to it,
ns of water till it begins to show turbidity; then filter;
ten times its bulk of water; and wash the resulting pre-
ld water by decantation or on the filter. The addition of
and filtration before the complete precipitation, is neces-
mall quantity of hydrosulphuric acid, which always remains
ied down by the first portions of oxychloride precipitated, and
ed to remain, it would cause the precipitate to turn yellow.
a heavy white amorphous powder; but if left to stand in
it, is converted into a mass of small shining oblique rect-
in composition according to the temperature of the water
and washing. According to Duflos and Bucholz, it is

$2SbCl^3.5Sb^2O^3$; according to Johnston, $4SbCl^3.9Sb^2O^3$; according to Schneider, $2SbOCl.Sb^2O^3$; according to Peligot, the precipitate formed in the cold is $SbCl^3.Sb^2O^3$, or SbO.Cl, (chloride of antimonyl), and after it has become crystalline by heating, $2SbCl^3.5Sb^2O^3$. Continued washing with water removes more and more of the chloride, ultimately leaving nearly pure antimonious oxide; alkaline-water removes the whole of the chloride. The oxychloride is also decomposed by heat, the chloride being volatilised and oxide remaining.

Antimonious oxide dissolves in about 15 times its weight of the boiling trichloride, and the solution on cooling solidifies into a pearly grey, perfectly crystalline mass, apparently consisting of $Sb^2OCl^4.6SbCl^3$, analogous to the sulphochloride formed in like manner (p. 338). It is decomposed by absolute alcohol, with separation of powder of algaroth. (Schneider, Pogg. Ann. cviii. 407.)

ANTIMONY, OXYIODIDE OF. Antimonious iodide is decomposed by water, yielding a white precipitate, which appears to be analogous in composition to the oxychloride. An oxyiodide, $2SbI^3.5Sb^2O^3$, is likewise obtained in gold-coloured spangles resembling iodide of lead, by adding iodine to a solution of tartar-emetic, or by treating the trichloride of antimony with solution of iodide of potassium, evaporating the solution, treating the residue with water, and repeating these operations several times. It is decomposed by heat. Hydrochloric acid dissolves it, with separation of iodine. It is slightly soluble in tartaric acid and cream of tartar. Nitric acid decomposes it, separating oxide of antimony. (Preuss, Pharm. Centr. 1839, p. 311.)

ANTIMONY, OXYSULPHIDE OF. The compound $Sb^2O^3.2Sb^2S^3$ occurs native as *Red antimony*, *Antimony blende*, *Kermesome*, *Rothspiessglanzerz*, in needles or tufts of capillary crystals belonging to the monoclinic system: Specific gravity = 4·5 to 4·6. Hardness = 1 to 1·5. It has a cherry-red colour and adamantine lustre, gives a brownish-red streak, and is slightly translucent, appearing scarlet by transmitted light. Melts very readily before the blowpipe, sinking into the pores of the charcoal, and volatilising in dense clouds. Ignited in a current of hydrogen, it yields hydrosulphuric acid, water, and metallic antimony (H. Rose, Pogg. Ann. iii. 452). It contains 74·5 to 74·7 Sb, 5·29 to 4·7 O, and 20·5 S. Occurs in veins in quartz, accompanying grey and white antimony, at Malaczka near Posing in Hungary, at Bräunsdorf near Freiberg, and at Allemont in Dauphiny. It appears to result from alteration of grey antimony ore. A similar compound, but of an orange-red colour and containing only 17·9 per cent. sulphur, sublimes when aqueous vapour is passed over the ignited trisulphide. (Regnault.)

Various oxysulphides of antimony may be prepared artificially. They were formerly much used in pharmacy for the preparation of tartar-emetic, but are now nearly obsolete. α. *Antimonial crocus* or *saffron* (*Crocus antimonii, s. metallorum*) is a brownish-yellow substance, prepared by fusing a mixture of 3 pts. of the trioxide and 1 pt. trisulphide of antimony, or an oxide of antimony with the proper proportion of sulphur. A similar compound, mixed however with variable quantities of antimonite of potassium, is obtained by treating the trisulphide with caustic alkalis (p. 332). β. *Glass of antimony* (*Vitrum antimonii*) is an oxysulphide prepared by roasting the grey sulphide at a moderate heat, till it is converted into the tetroxide, and fusing this *antimony ash* in an earthen crucible, with about $\frac{1}{20}$ of its weight of sulphur. It is a brilliant substance, varying in colour from yellowish-red to hyacinth-red, according to the proportions used. It gives up its oxide to acids, and evolves sulphuretted hydrogen when treated with hot hydrochloric acid. γ. A compound of trisulphide of antimony with a very small portion of oxide, called *Regulus antimonii medicinalis* or *Rubinus antimonii*, is obtained by fusing 5 pts. of the grey sulphide with 1 pt. of pearl-ash, and separating the upper stratum (consisting of sulphantimonite of potassium) from the lower. It is a black mass, having a brilliant conchoïdal fracture, and yielding a dark grey powder.

According to Liebig, mineral kermes prepared by the action of alkaline carbonates on the amorphous trisulphide, is a definite oxysulphide of antimony (see p. 328); but kermes obtained by most other modes of preparation, appears to contain the oxide merely in a state of mixture with the sulphide.

ANTIMONY, SELENIDE OF. Antimony and selenium unite when heated together, to a lead-grey crystalline mass, the combination being attended with rise of temperature, often amounting to ignition. The same compound is formed by precipitating a solution of tartar-emetic with seleniuretted hydrogen; hence its formula is probably Sb^2Se^3. Selenide of antimony is easily fusible, and oxidises when heated in the air, giving off selenious acid. Heated with trioxide of antimony, out of contact with the air, it melts into a mass resembling the fused sulphide.

IDES OF. Antimony forms two sulphides, Sb^2S^2 and
monious and to antimonic oxide, and perhaps also an
onding to the tetroxide.

IMONY, ANTIMONIOUS SULPHIDE, ANHYDROUS
, Sb^2S^3, or SbS^3.—This compound exists in the crystalline

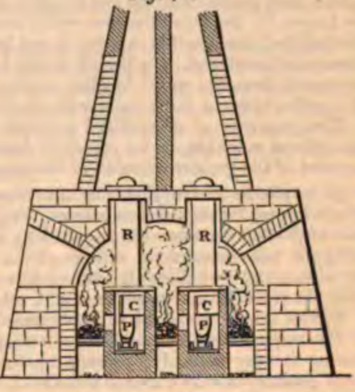
ide occurs as a natural mineral called stibnite, stibine, grey
Spiessglanz, *Grauspiessglanzerz*, *Antimoine sulfuré*, *Leo*
us metallorum). It is the source of all the antimony of
arious localities in Hungary, Germany, and France, also
, in Maine, Maryland, and New Hampshire (U. S.), and
ys associated with the older rocks, such as gneiss, quartz,
one, porphyry, &c., whence it is separated by simple
imony of commerce.

ide from the accompanying gangue is effected in various
ment is that which is in use at Malbosc in the depart-
nd at Wolfsberg in the Harz. A number of conical pots,
anding upon receivers sunk in the ground, are placed
, between walls about nine inches high, the space be-
ith coal, and the fire lighted with brushwood. Each pot
of ore, and in forty hours four meltings are made, suffi-
he advantages of this method are that it saves the ex-
nd may be carried on at any place to which the ore and
orted. But it involves a large consumption of fuel, and
ly where fuel is very abundant. At Malbosc the con-
of coal and 40 kil. of wood, for every 100 kil. of crude

different from the above, consists in heating the conical
beratory furnace, the receivers being placed below the
also in use at Wolfsberg, and at La Lincouln in Haute
ungary, the pots are likewise heated by a reverberatory
ide runs through a channel into receivers placed outside
nt effects a considerable saving of time and fuel, as it
nd emptied without putting out the fire.

al tubes are used in preference to conical pots, as being
ent of this
The ore
R R (*fig.*
ds of ore,
ch furnace.
ed at bot-
ierced with
neath these
are placed
the melted
three hours,
residues are
the top of
tures in the
(which are
e melting),
re refilled.
. of coal are
s. of crude
s heated on
y furnace, without the use of either pots or cylinders.
hearth, and the fused sulphide flows into a receiver
ement, which is in use at Linz, in Prussia, and at Ramé
saving of fuel, and likewise does away with the expense
t it involves a considerable loss of sulphide of antimony
fore adopted only where fuel is very dear.

Fig. 71.



y be adopted, it is important that the ore be not broken
be too much divided or pulverised, the melted sulphide
ue, and is very difficult to separate. Too great heat must
te heat, sulphide of antimony is perfectly volatile. The
12 per cent. of antimony, partly as sulphide, partly as

oxide. [For further details, see Bruno Kerl's "Handbuch der metallur Hüttenkunde," Freiberg, 1858, iii. 25.]

Native sulphide of antimony crystallises in prisms belonging to the trimetric s with four-sided summits resting on the lateral faces. Cleavage very distinct, p to the shorter diagonal and the principal axis. Specific gravity 4·516 (Haüy) (Mohr). Hardness = 2. It is sectile, and in thin laminæ slightly flexible; f subconchoïdal. It has a metallic lustre and lead-grey colour, inclining to stee sometimes iridescent. Produces a streak of the same colour. The fused s generally forms blackish-grey, radiating, specular masses, having a steel-grey It is easily fusible, thin splinters melting even in the flame of a candle.

The native sulphide is seldom pure, being generally contaminated with lead, iron and arsenic. Wittstein found in four samples of *crude antimony:*

	a	*b.*	*c.*	*d.*
Antimony	62·48	59·67	70·26	71·98
Lead	10·40	11·96		
Iron	0·70	0·63	0·31	
Arsenic	trace	trace		
Sulphur	26·42	27·74	29·43	28·02
	100·00	100·00	100·00	100·00

a. Iridescent, from Kronach in Upper Franconia; *b.* Non-iridescent, from th locality; *c.* Hungarian; *d.* English.

The best way of detecting these impurities is to heat the finely pulverised with strong hydrochloric acid, till it is completely decomposed. Lead, if pre any considerable quantity, will then separate on cooling, as crystallised chloride added to the solution will throw down oxychloride of antimony, while iron, arsenic, and a little lead will remain in solution; copper may then be detec ammonia, iron by ferrocyanide of potassium, lead by sulphuric acid.

To detect arsenic, the pulverised mineral is deflagrated with nitrate and car of sodium; the fused mass boiled with water, the filtrate acidulated with hydro acid, and sulphurous acid added to reduce the arsenic acid to arsenious acid, may then be precipitated by sulphuretted hydrogen. The precipitate, however likewise contain sulphide of antimony, and must therefore be further examined

To obtain *pure* crystallised trisulphide of antimony, it is best to prepare ficially, by fusing pure metallic antimony with sulphur. 13 pts. of finely pul antimony are mixed as intimately as possible with 5 pts. of flowers of sulphur, a mixture is thrown by small portions into a heated crucible, care being taken add a fresh portion till the combination of the last portion is completed, whic be known by the incandescence which accompanies the action. When the who been added, the crucible is covered and left to cool. If any portion of the an remains uncombined, it will sink to the bottom of the fused mass, and may ea separated from the sulphide after cooling. It is sometimes recommended to the product two or three times with smaller quantities of sulphur.

The *reactions* of crystallised sulphide of antimony are the same as those amorphous sulphide, to be presently described: but they take place less quick account of the greater cohesion of the mass.

Amorphous Trisulphide of Antimony, Mineral Kermes.—Brown-red su of Antimony, Pulvis Carthusianorum, Sulphur stibiatum rubrum, Stibium sulphu rubrum.—This substance is prepared by a great variety of processes, some of yield the pure trisulphide, differing from the native compound only in colour a the absence of crystalline structure, while others yield the sulphide more or less with the trioxide, and sometimes with other antimonial compounds.

a. The pure amorphous sulphide may be obtained by the following proces 1. By keeping the grey trisulphide in the fused state for a considerable time, an cooling it very suddenly by throwing the vessel in which it has been melted large quantity of cold water (Fuchs).—2. By dissolving the native sulphide in p ley, and precipitating by an acid (Liebig).—3. By igniting 1 pt. of *crude antimon* 2 pts. of black flax (a mixture of 1 pt. nitre, and 2 pts. cream of tartar), boili ignited mass with water, and mixing the clear filtrate with an alkaline carb whereby the pure amorphous sulphide is precipitated (Liebig).—4. By the d position of alkaline sulphantimonites (livers of antimony).—5. By treating m kermes containing oxide of antimony, with tartaric acid, whereby the oxi dissolved out.

b. Mineral Kermes containing oxide is obtained by the action of alkalis on th sulphide. The oldest method, given by La Ligérie, consists in boiling the pulverised grey sulphide with the solution of an alkaline carbonate, and leavin

same process is given in the last edition of the Prussian
, crystallised sulphide of antimony dissolves but slowly in
ter first to convert the crystallised into the amorphous
rmes from the latter. The following is the process given
n. 2^{te} Aufl. ii. 121).

rey sulphide is boiled for an hour with 1 part of solid
water (or 1 pt. of the grey sulphide with 4 pts. potash-ley
12 pts. water, or 1 pt. sulphide, with 1 pt. carbonate of
me, and 15 pts. water), and the filtered liquid is mixed
hereby amorphous sulphide of antimony is precipitated.
divided into three parts, and covered with water in three
itate is left to settle; the water is decanted; and fresh
tates are well washed: they are then placed upon three
ydrous (or 2·7 pts. of crystallised) carbonate of sodium is
vater; the precipitate from the first of the three filters is
lution; the liquid is boiled for an hour; and the solution,
lphide of antimony, is left to cool, whereupon it deposits
quid is now brought to the boiling heat, the second pre-
d treated in the same manner, and finally the same
the third. The finest coloured kermes is deposited from
cipitates are washed with cold water: their weight after
half of the grey sulphide used. [For the rationale of the
OF SULPHIDE OF ANTIMONY, p. 333.]

boiling the grey sulphide with caustic potash or soda
provided the alkali is not in great excess; and by boiling
after the deposition of the kermes with the undissolved
e, fresh deposits, smaller in quantity, may be obtained.
ution obtained by boiling 100 pts. of grey sulphide for
solution of 30 parts of hydrate of potassium in 300 pts.
25 pts. of kermes; a second boiling of the mother-liquor
y sulphide yields 10 pts.; a third yields 2·3 pts. The
ed are continually richer in oxide of antimony.

nuch alkali as not to yield any deposit on cooling, yields
carbonic acid gas is passed through it, and afterwards
treated with strong acids. The precipitate thus formed
de, and always a sulphantimonate of potassium or sodium,
se, according to H. Rose, part of the antimony is oxidised
ulphur to the trisulphide of antimony, thereby converting

btained by boiling sulphide of antimony with potash-ley
solution of sulphantimonite of sodium with metallic anti-
l other modes of preparation, for which we must refer to
pp. 340—349, where they are fully described. The pre-
different methods, are, however, by no means identical;
ions of oxide of antimony, and many of them likewise
tassium or sodium.

rphous trisulphide obtained by Fuchs's method is a dense
e native sulphide, having a conchoïdal fracture, a grey
k hyacinth-red, and yielding a red-brown powder some-
ordinary kermes; its specific gravity is 4·15. The pure
d by other methods is a brown-red, loosely coherent
a streak on paper. It is lighter than the native sulphide,
ity. It contains water, which it gives off below 100° C.
e with cold hydrochloric acid, or when fused and very
into the crystalline sulphide.

ng oxide is a brown-red loose powder, which becomes
ith boiling water. By fusion and slow cooling, it is con-
totally destitute of crystalline structure, a property by
om the pure amorphous sulphide.

Antimony.—The amorphous sulphide is obtained as
ted hydrogen through an acid solution of the trichloride
ar-emetic acidulated with acetic acid. The precipitate at
he trichloride acidulated with tartaric acid, is a mixture of
ychloride; but on continuing the passage of the gas, it be-
is completely converted into the hydrated sulphide. The
nposing a solution of sulphantimonate of potassium with
so the hydrated sulphide.

Hydrated trisulphide of antimony when dry has a fine dark orange-colour. It gives off water when moderately heated, but to dehydrate it completely, requires a temperature of 200° C. it then turns black. At higher temperatures, it melts and solidifies in the crystalline form on cooling.

Decompositions of Trisulphide of Antimony.—The reactions of this compound are nearly the same, whether it be in the crystalline or in the amorphous state, the crystalline variety merely acting less quickly on account of its closer state of aggregation.—1. The dry amorphous sulphide touched with a red-hot body burns away in the *air* with a glimmering light, producing sulphurous anhydride, antimonious oxide, and antimonic oxide; the grey sulphide heated above its melting point, burns with a blue flame, yielding the same products.—2. The recently precipitated amorphous sulphide is decomposed by boiling for some time with a large quantity of *water*, yielding hydrosulphuric acid and antimonious oxide, which dissolve. Vapour of water passed over red-hot sulphide of antimony likewise yields hydrosulphuric acid and antimonious oxide, the latter combining with undecomposed sulphide, and an orange-yellow body subliming.

3. *Chlorine*, with the aid of heat, *decomposes* the trisulphide completely, forming trichloride of antimony and chloride of sulphur.—4. Heated in *hydrochloric acid gas* or boiled with the strong aqueous acid, it gives off hydrosulphuric acid, and forms trichloride of antimony, which in the latter case dissolves in the excess of acid.—5. With *strong sulphuric acid*, it yields sulphurous anhydride and antimonious sulphate, the sulphur being separated as a compact mass.—6. With *strong nitric acid*, it forms antimonious oxide and sulphuric acid, part of the sulphur, however, being set free and remaining mixed with the oxide.—7. *Aqua-regia* containing excess of hydrochloric acid dissolves the trisulphide, forming trichloride of antimony and sulphuric acid, and leaving a residue of sulphur often mixed with a little antimonic acid.—8. The trisulphide ignited with *nitrate of potassium or sodium*, is violently oxidised, being completely converted into sulphuric and antimonic acids, if 17 pts. or more of nitre are used to 10 of antimony; with less nitre, a compound of sulphide of potassium, sulphide of antimony and antimonic oxide is likewise formed.—9. Many metals, *e. g. iron*, *potassium*, and *sodium* (or a mixture of carbonate of potassium or sodium with charcoal), decompose sulphide of antimony at a red heat, the resulting metallic sulphide sometimes uniting with undecomposed sulphide of antimony; if, on the other hand, the reducing metal is in excess, it sometimes forms an alloy with the reduced antimony.

10. The *fixed caustic alkalis* decompose trisulphide of antimony in the same manner in the wet and in the dry way, forming trioxide of antimony and a sulphide of the alkali-metal:

$$Sb^2S^3 + 3K^2O = 3K^2S + Sb^2O^3,$$

but the final products of the action vary according to the state of aggregation of the antimonious sulphide, the temperature to which the mixture is exposed, and the proportions of the two substances present. *a.* When amorphous sulphide of antimony, prepared in the wet way, is triturated with cold potash-ley, it dissolves *completely* up to a certain point, the sulphide of potassium formed as above, taking up undecomposed sulphide of antimony, and the antimonious oxide dissolving in the potash. This solution contains sulphantimonite and antimonite of potassium. When treated with acids, it yields a precipitate of antimonious sulphide, without evolution of sulphuretted hydrogen, because the quantity of that compound evolved by the decomposition of the sulphide of potassium present, is but just sufficient to convert the trioxide of antimony into trisulphide. But if the addition of the trisulphide be continued, a point is at length reached, at which the alkaline liquid cannot take up any more antimonite of potassium, and any further quantity of antimonious oxide then formed remains undissolved, partly combined with potash, partly with antimonious sulphide, forming the mixture called *crocus antimonii* (328). The *incomplete* solution thus formed contains, however, a larger proportion of sulphide of potassium than the complete solution, the excess being proportional to the quantity of oxide left undissolved. This excess of sulphide of potassium takes up an additional quantity of sulphide of antimony, and the solution treated with acids, evolves sulphuretted hydrogen, besides giving a precipitate of antimonious sulphide. The *complete* solution mixed with carbonate of ammonium, or with acid carbonate of potassium or sodium, yields a dirty brown precipitate consisting of 3 at. antimonious sulphide with 1 at. sulphide of potassium or sodium, a portion of the alkaline sulphide also remaining in the liquid. The greater part of the alkaline antimonite is likewise precipitated, because the caustic alkali which held it in solution is converted into neutral carbonate. The precipitation of the antimonious oxide, is, however, partly caused by its affinity for the sulphide of antimony previously thrown down in combination with the alkali-metal. The *incomplete* solution is decomposed in like manner, but the precipitate contains a

ic oxide. The *complete* solution rapidly absorbs oxygen
potassium is first decomposed, yielding oxide of potas-
ıen converts the trisulphide of antimony into penta-

$$Sb^2S^3 + O^2 = 2K^2O + K^2S.Sb^2S^5$$

ith acids yields a precipitate of pentasulphide of anti-
antimonite of potassium is converted into antimonate,
ıe bottom.
hide in excess is digested with *hot caustic alkalis*, the
as in the cold, excepting that the sulphide of potassium
tion of antimonious sulphide, the excess of which is sub-
; not, however, in the pure state, but in combination,
, partly with antimonious oxide, the composition of the
ilar to that which is produced by alkaline bicarbonates
f antimonious sulphide. The supernatant liquid gives
precipitate of alkaline sulphantimonite free from oxide.
nentioned are altered in composition by prolonged treat-
ing air, or with boiling water, antimonious oxide being
with alkali, and pure dark-coloured antimonious sulphide

sulphide is acted upon by *caustic alkalis* in the same way
out less easily, and when the action takes place in the
imonii is always left, whatever may be the quantity of
solution exhibits the reactions of the *incomplete* solution

used with antimonious sulphide, either crystalline or
nhydride, and form antimonious oxide and a sulphide of
ass containing these products in combination with excess
alkali. With 4 pts. antimonious sulphide and 1 pt.
usible mass is formed, which, after cooling, has an iron-
geneous, and *is not attacked by water*. A mixture of
nonious sulphide requires a strong red heat to melt it,
cent. of metallic antimony, together with a light brown
quesces in the air, and is *perfectly soluble in water*. The
timony results from decomposition of the alkaline anti-
s, part of it being converted into antimonate. With
mixture fuses more readily, and the resulting liver of
ter as the proportion of antimonious sulphide is greater.
the excess of antimonious sulphide in combination with
ide and with antimonious oxide; it is, in fact, similar in
ared in the wet way, but generally contains more sulphide
n these livers of antimony exactly in the same manner
lkalis act upon antimonious sulphide under the same

ates do not act on antimonious sulphide in the cold, but
solve the amorphous sulphide readily, the crystalline
epared out of contact with the air, contains the same
on of the amorphous sulphide in cold potash-ley (p. 332).
and deposits a grey-brown precipitate similar in compo-
ed by alkaline bicarbonates in the cold complete solution
fact, of two compounds, viz. an alkaline sulphantimonite
ny. The liquid, after the separation of this precipitate,
aline sulphide.
us sulphide in hot alkaline carbonate be boiled for some
art of the alkaline sulphide becomes oxidised, and gives
issolved trisulphide of antimony, thereby converting it
ains in solution after cooling. The quantity of anti-
ate remains the same, but the proportion of antimonious
the quantity thus retained in solution. The proportion
ewise diminished by the oxidation. The quantity of
ecipitate is now not only sufficient to replace all the
tion with the precipitated antimonious sulphide, but a
timonite likewise remains free in the liquid; and there
trioxide and trisulphide of antimony, which is the true
nerally, however, mixed with small quantities of alkaline

Kermes prepared in this manner, contains, under all circumstances, a tolerabl constant quantity of antimonious oxide, because, when alkaline carbonates are used, the portion of sulphide of antimony attacked by them passes *completely* into the solution, without leaving any residue, and consequently the entire quantity of the products thu formed is likewise contained in the liquid. (Liebig, Handwört. d. Chem. 2^{te}. Aufl. ii 125—130.)

12. By ignition with *baryta*, *strontia*, *lime*, and other *oxides*, antimonious sulphide is decomposed in the same manner as by caustic and carbonated alkalis: the products are insoluble in water, and consist of mixtures of metallic sulphantimonites with a oxysulphide of antimony.

Sulphantimonites.—Trisulphide of antimony is a sulphur-acid, uniting with basic metallic sulphides. Some of these compounds, containing the sulphides of the heavy metals, are natural minerals, viz.:

Zinkenite	$PbS . Sb^2S^3$
Miargyrite	$Ag^2S . Sb^2S^3$
Antimonial Copper-glance	$Cu^2S . Sb^2S^3$
Plagionite	$4PbS . 3Sb^2S^3$
Jamesonite	$3PbS . 2Sb^2S^3$
Feather-ore	$2PbS . Sb^2S^3$
Boulangerite	$3PbS . Sb^2S^3$
Pyrargyrite	$3Ag^2S . \left.\begin{matrix}Sb^2\\As^2\end{matrix}\right\}S^3$
Bournonite	$3(Cu^2S.Sb^2S^3) + 3PbS.2Sb^2S^3)$
Fahl-ores	$2\begin{pmatrix}ZnS\\FeS\end{pmatrix} + \begin{pmatrix}Sb^2S^3\\As^2S^3\end{pmatrix}$
Stephanite	$6Ag^2S . Sb^2S^3$
Polybasite	$9\begin{pmatrix}Ag^2S\\Cu^2S\end{pmatrix} + \begin{pmatrix}Sb^2S^3\\As^2S^3\end{pmatrix}$
Berthierite	$3FeS . 2Sb^2S^3$
Variety of Berthierite, from Anglar	$FeS . Sb^2S^3$
Variety of Berthierite, from Marturet	$3FeS . 4Sb^2S^3$

In these formulæ, the elements whose symbols are written one above the other, replace one another isomorphously. [For description, see the names of the several minerals.]

The most important of the artifically prepared sulphantimonites are those which contain the protosulphides of the alkali-metals: they are called Livers of Antimony (*Hepar Antimonii*). They are obtained, mixed with oxide in various proportions, by fusing the trisulphide of antimony with alkaline carbonates, or metallic antimony with sulphate of potassium; and free from oxide, by melting sulphide of antimony with alkaline sulphates and charcoal, or with alkaline carbonates, sulphur and charcoal, or again by melting sulphantimonate of sodium with metallic antimony.

These alkaline sulphantimonites, or livers of antimony, are easily fusible, and deliquescent or unalterable in the air, according to the proportion of the alkaline sulphide and the antimonious sulphide contained in them. They are more or less soluble in water, when the ratio of the antimonious sulphide to the alkaline sulphide is less than 2 : 1; insoluble, when it is greater.

In the fused state, they are black or black-brown and crystalline. Their solutions boiled with pulverised antimonious sulphides, dissolve an additional quantity of it, which on cooling is deposited as a flocculent precipitate containing also the alkaline sulphide. Acids added to the solutions throw down the amorphous sulphide; so likewise does carbonate of ammonium. Alkaline bicarbonates immediately throw down sulphantimonite of potassium or sodium; the solution mixed with an alkaline monocarbonate, remains clear at first, but solidifies after a while to a tremulous jelly containing the same compound. The same effect is produced when the aqueous solution of a liver of antimony is diluted with a large quantity of cold water. The solution of a liver of antimony changes very quickly when exposed to the air, a sulphantimonate being formed in solution, and a portion of the trisulphide of antimony being separated in brown metallic films or as a powder.

Pentasulphide of Antimony; Antimonic Sulphide; Anhydrous Sulphantimonic Acid.—*Persulphide of Antimony; Golden Sulphuret of Antimony; Sulphur Antimonii auratum*, Sb^2S^5, or SbS^5.—This compound is not found native. It is prepared: 1. By passing sulphuretted hydrogen through a mixture of the pentachloride with water and tartaric acid, or through antimonic oxide suspended in water.—2. By decomposing the solution of the sulphantimonate of an alkali-metal with an acid, the sodium-salt, for example, whereby the sulphide of sodium is decomposed, a salt ned, with evolution of sulphuretted hydrogen, and penta-

^{5} + 6HCl = 6NaCl + 3H^{2}S + Sb^{2}S^{5}.
te

andbook, iv. 355; Handwörterb. d. Chem. 2te Aufl. ii.

is a yellowish-red powder, or loosely agglomerated mass,
line structure; it has a very feeble odour of sulphur, a
d is slightly emetic. Heated in close vessels to the boil-
solved into the trisulphide and free sulphur. It burns
ne air. Exposed to the air in the moist state, it is partly
the trioxide of antimony.—Hot *hydrochloric acid* decom-
ed hydrogen, separating sulphur, and forming an aqueous
timony; cold hydrochloric acid imparts to it a greyish
e of the formation of the trisulphide and liberation of
ut of contact of air, with aqueous *ammonia*, it dissolves
warm acid than in a cold solution, and is precipitated
pentasulphide contains trisulphide, the latter remains as
white residue, on the other hand, indicates the presence
oxide.—The pentasulphide dissolves readily in *potash* or
f *ammonium*. With a solution of sulphate of *copper* or
hantimonate of copper or silver, together with antimonic

tasulphide of antimony is a strong sulphur-acid, uniting
metallic sulphides, and forming sulphur-salts, most of
3M^{2}S.Sb^{2}S^{5}, or M^{3}SbS^{4} or 3M″S.Sb^{2}S^{5} = (M″)^{3}Sb^{2}O^{8}, ana-
tribasic phosphates (M^{3}PO^{4}). The sulphantimonates of
e earth-metals are very soluble in water, and crystallise
l atoms of water; none of them appear to be soluble in
tes of the heavy metals are insoluble in water.
es are obtained:—1. By fusing pentasulphide of antimony
de and sulphur, with the sulphide of an alkali-metal, or
ate or sulphate of an alkali-metal. If a strong heat is
to the trisulphide is unnecessary, as at high temperatures
to metallic antimony and the pentasulphide.—2. By dis-
mony in aqueous solutions of the alkaline hydrosulphates.
sulphide in the solution of a caustic alkali, or of an alkaline
t; in which process an antimonate of the alkali-metal
l deposited as a white powder.—4. By decomposing the
ine antimonates with hydrosulphuric acid, $\frac{2}{3}$ of the anti-
d as pentasulphide, because the alkaline antimonates are
monates tribasic:

18H^{2}S = 3K^{2}S.Sb^{2}S^{5} + 18H^{2}O + 2Sb^{2}S^{5}.
9H^{2}S = K^{3}SbS^{4} + 9H^{2}O + Sb^{2}S^{5}.

nates are prepared by gradually adding a solution of a
the sulphantimonate of an alkali-metal, that of sodium
the latter in excess. If, on the other hand, the solution
and especially if the liquid be boiled, the resulting pre-
the liquid is found to contain free acid. The precipitates
3M^{2}S.Sb^{2}S^{5} + 5M^{2}O, or rather 8M^{2}S + Sb^{2}O^{5}, being, in
tallic sulphide with antimonic oxide, the latter being
bility. (Rammelsberg, Pogg. Ann. lii. 193.)
tes are decomposed by all acids, even by carbonic acid,
d hydrogen. Many of the insoluble salts are decomposed
regia. The sulphantimonates of the alkali-metals are not
sed vessels; those of the heavy metals give off sulphur
ntimonites containing 3M^{2}S.Sb^{2}S^{3}, or M^{3}SbS^{3}.

mmonium, 3(NH^{4})^{2}S.Sb^{2}S^{5}, or (NH^{4})^{3}SbS^{4}, is produced
f antimony in excess with pure sulphide of ammonium,
. It cannot be obtained in the solid state, being decom-
even out of contact with the air, and by mixture with

arium, Ba^{3}Sb^{2}S^{8} + 3H^{2}O.—Obtained by dissolving recently precipitated prosulphide of antimony in sulphide of barium, and mixing th solution with alcohol, in stellate needles, which, when exposed to the air, do n deliquesce, but become covered with a brown kermes-coloured film.

Sulphantimonate of Bismuth is obtained by precipitation, but is not easi obtained free from excess either of pentasulphide of antimony or of sulphide of bismut

Sulphantimonate of Cadmium.—Light orange-coloured precipitate obtained dropping a neutral cadmium-salt into a solution of sulphantimonate of sodium.

Sulphantimonate of Calcium. Sulphostibias-calcicus. $Ca^3Sb^2S^8$.—Produc like the barium-salt, but cannot be crystallised. A mixture of this compound wi excess of lime and saffron of antimony, constitutes the pharmaceutical preparati known as *Calx antimonii cum sulphure Hoffmanni*, *Sulphuretum stibii cum calc*, *Calcaria sulphurata stibiata*, discovered by Hoffmann in the eighteenth century. is prepared by igniting an intimate mixture of 3 pts. trisulphide of antimony, 4 p sulphur, and 16 pts. quicklime; or 8 pts. of prepared oyster shells, 1 pt. antimon and 2 pts. sulphur. It is a whitish-yellow, yellowish, or brownish-yellow powder, whi has a sharp sulphurous taste, smells of sulphuretted hydrogen when exposed to mo air, and is but partially soluble in water. The solution is colourless, and contai sulphantimonate of calcium.

Sulphantimonate of Cobalt, obtained by precipitation, is black, oxidises in t air, and is decomposed by boiling hydrochloric acid.

Sulphantimonate of Copper. $Cu^3Sb^2S^8$.—Obtained by dropping a solution cupric acetate or sulphate into a solution of sulphantimonate of sodium. The solutio must be rather dilute; the copper-solution must be dropped in slowly and with rap stirring; and the precipitate then heated, together with the liquid, with brisk stirri all the while. Without these precautions, each drop of the copper-solution, as enters, becomes enveloped by the precipitate; and if the precipitate be thrown on t filter in this state, the solution of sulphantimonate of sodium runs away first, and th the acetate of copper and sulphantimonate of copper decompose each other, acetic ac or sulphuric acid being set free, which then acts upon the sulphantimonate of sodiu still remaining in the precipitate, setting free pentasulphide of antimony and hydr sulphuric acid. In this manner, the precipitate becomes contaminated with pentasu phide of antimony and sulphide of copper.—Sulphantimonate of copper, when pure, a dark brown precipitate, which when heated gives off sulphur, and leaves a residu apparently consisting of cuprous sulphantimonite (Sb^2S^3 with Cu^4S). Boiling pota decomposes the sulphantimonate, separating sulphide of copper and dissolving pent sulphide of antimony, which is at the same time partially converted into antimon acid.

If sulphantimonate of sodium be added to excess of cupric sulphate, and the pr cipitate boiled for some time with the liquid, a product is obtained containing 16 a copper, 8 at. sulphur, 2 at. antimony, and 5 at. oxygen, and the liquid exhibits strong acid reaction:

$$3Na^2S.Sb^2S^5 + 8Cu''SO^4 + 5H^2O = (8Cu''S + Sb^2O^5) + 3Na^2SO^4 + 5H^2SO^4.$$

The precipitate thus formed, may, as already observed (see above), be either $3Cu''S.Sb^2S$ $+ 5Cu''O$, or $8Cu''S + Sb^2O^5$. On boiling it with potash-ley, sulphide of coppe remains behind, and a solution of antimonate of potassium is formed, which gives wit acids a white precipitate of antimonic acid. On the other hand, the precipitate, whe quickly and strongly heated in close vessels, gives off a large quantity of sulphurou anhydride, but no sulphur, and the residue contains sulphide of copper and pentasu phide of antimony. Moreover the same products are obtained by igniting a mixtur of 8 at. pure sulphide of copper, and 1 at. pure antimonic oxide, or of 1 at. sulphantimonate of copper and 5 at. cupric oxide. So far then it is impossible to decide upon th constitution of the precipitate obtained in the manner just described. But whe sulpharsenate of potassium is dropt into excess of cupric sulphate, and the mixtur boiled, a precipitate is obtained consisting of pure sulphide of copper, the whole o the arsenic remaining dissolved as arsenic acid. Hence, from the analogy of th arsenic and antimony compounds, it is probable that the antimony precipitate abovementioned is a mixture of sulphide of copper and antimonic oxide.

Sulphantimonate of Iron.—Ferrous sulphate dropt into sulphantimonate sodium forms a black precipitate, which quickly turns reddish-yellow. The sodium-sal forms with ammonio-ferric sulphate, so long as the latter is in excess, a greenish-brow precipitate, consisting merely of sulphur and pentasulphide of antimony, the whole o the iron being reduced to the ferrous state and remaining in the liquid.

Sulphantimonate of Lead. $Pb^3Sb^2S^8$.—Obtained by adding acetate of lea to sulphantimonate of sodium, with the same precautions as those described for th

alt. It is a dark brown precipitate, which is decomposed
phur, and leaving sulphantimonite of lead, $3Pb''S.Sb^2S^3$, or
position as the mineral Boulangerite. Boiling potash-ley
manner as the copper-salt. A precipitate, containing 8Pb,
obtained by adding sulphantimonate of sodium to excess

Magnesium.—Recently precipitated pentasulphide of
ous hydrosulphuric acid, in which magnesia is suspended,
lving; but the compound cannot be made to crystallise.

Manganese.—Red-brown precipitate, produced by mix-
ulphate of manganese; it oxidises during washing and

Mercury.—The *mercuric salt*, $3Hg''S.Sb^2S^5$, or $Hg^3Sb^2S^8$,
d lead-salts, is an orange-coloured precipitate. If after
solution of mercuric chloride, or a solution of sulphanti-
to excess of mercuric chloride, a white substance is formed,
$3Hg''Cl^2 + 3Hg''O$. This substance is not a mere mixture,
which is not attacked by any acid except aqua-regia.
liately, leaving mercuric sulphide, and dissolving antimonic
ercurous nitrate, mixed with sulphantimonate of sodium,
hichever salt may be in excess.

ickel.—Black precipitate, which oxidises in the air, and
chloric acid.

otassium, K^3SbS^4; in the crystallised state $2K^3SbS^4$ +
O.—The anhydrous salt is obtained by fusing sulphide of
of antimony and sulphur, or sulphate of potassium with
, or by heating one of the potassium-livers of antimony,
nony separates out. The product is a brown mass, the
elds crystals of the hydrated salt. The latter is, however,
mixture of 11 pts. of finely levigated trisulphide of anti-
potassium, 1 pt. of flowers of sulphur, and 3 pts. of lime
d, with 20 pts. of water, for some hours, renewing the
by leaving the same mixture in a covered vessel for 24
y; then filtering and evaporating. The hydrated salt
, granular or radiating crystals, which give off their water

sium is likewise formed when pentasulphide of antimony
nate of potassium, antimonate of potassium being formed
ating in the solid state. Hot caustic potash-ley dissolves
; but on diluting the solution, and adding carbonate of
ormed, consisting merely of the pentasulphide mixed with
ntimonate of potassium. Cold potash-ley of moderate
hide of antimony somewhat differently; the pentasulphide
ntimonate of potassium ($K^2O.2Sb^2O^5 + 6H^2O$) remains
the excess of potash present; free sulphide of potassium
elds by evaporation a colourless double salt, consisting of
nate of potassium ($K^3SbS^4.KSbO^3 + 5H^2O$), crystallising
n exposed to the air, become covered with a kermes-
enders these crystals milk-white, dissolving a portion, and
id antimonate of potassium. Hot water dissolves the salt
en mixed with acids, yields an orange-coloured precipitate,
f antimony mixed with antimonic acid.

ilver, Ag^3SbS^4, prepared like the lead- and copper-salts
oluble precipitate, which gives off sulphur when heated,
of sulphantimonate of silver, Ag^3SbS^3, which yields a red
adding sulphantimonite of sodium to excess of nitrate of
hours, a precipitate is obtained containing antimonic oxide,
tracted from it by potash.

Sodium, $Na^3SbS^4 + 9H^2O$, or $3Na^2S.Sb^2S^5 + 9H^2O$.
s prepared by digesting at ordinary temperatures in a
l with frequent stirring, a mixture of 11 pts. of elutriated
pts. crystallised carbonate of sodium, 1 pt. flowers of
previously slaked, and 20 pts. of water. After twenty-four
off, the residue washed several times with water, and the

solution together with the wash-water, is evaporated in a porcelain dish or clean iron pot, till a sample yields crystals on cooling. The whole is then left to cool quietly, and the resulting crystals are washed several times with cold water, and dried in the air, or better, under a bell jar, over lime or oil of vitriol. The formation of the salt is much accelerated by boiling the mixture. (**Liebig**, Handwört. d. Chem. 2^{te} Aufl. ii. 139. For other modes of preparation, see Gmelin's Handbook, iv. 384.)

Sulphantimonate of sodium forms transparent, colourless, or pale yellow, regular tetrahedrons, with truncated summits, or acuminated with the faces of the rhombic dodecahedron. Its taste is bitterly metallic, and at the same time alkaline. It dissolves in 2·9 pts. of water at 15° C., and the solution is precipitated by alcohol. When heated, it melts in its water of crystallisation, and after all the water has gone off, forms a greyish-white mass, which crumbles to a bulky powder when exposed to the air. At a commencing red heat, it fuses, without decomposition, if the air be excluded. The fused mass is liver-coloured, and dissolves in water, leaving a small quantity of sulphide of antimony. The decomposition of the solution, as well as of the salt itself, by contact with the air, is due to the action of carbonic acid, but is not complete even after many months. The resulting brown precipitate contains sulphantimonate of sodium with trisulphide of antimony, and the liquid is found to contain carbonate, sulphide, and hyposulphite of sodium, but no sulphate.

When sulphantimonate of sodium is added to a solution of tartar-emetic, the liquid first turns red, and then yields an orange-coloured precipitate containing pentasulphide, trisulphide, and trioxide of antimony, while tartrate of sodium and potassium remains in solution:

$$6C^4H^4KSbO^7 + 2Na^3SbS^4 = 6C^4H^4KNaO^6 + Sb^2S^5 + Sb^2S^3 + 2Sb^2O^3$$

This precipitate melts at a high temperature, forming a black metallic-shining mass, exhibiting red translucence on the edges, and perfectly soluble in hydrochloric acid. Potash decomposes it, leaving a yellow residue consisting of sulphide of sodium, trioxide of antimony, and a compound of that oxide with potash. (Handwörterbuch.)

Sulphantimonate of Strontium.—Prepared like the calcium-salt: not crystallisable.

Sulphantimonate of Uranium.—Yellow-brown precipitate, obtained by adding ammonio-uranic chloride to sulphantimonate of sodium.

Sulphantimonate of Zinc, obtained by dropping sulphate of zinc into a solution of the sodium-salt, is an orange-coloured precipitate which dissolves in the liquid when heated, and partly runs through the filter during washing. It is decomposed and dissolved by hydrochloric acid.

The precipitate obtained with excess of the zinc-salt, has the same colour, but is not easily obtained free from the preceding, even after long boiling. Fuming nitric acid decomposes it, with ignition. (Handwörterbuch.)

ANTIMONY, SULPHOCHLORIDE OF. $SbSCl^3$. Obtained by slowly passing dry sulphuretted hydrogen into pentachloride of antimony. It is a white crystalline body, which melts at a moderate heat, is resolved at a higher temperature into sulphur and trichloride of antimony, deliquesces in moist air, and is decomposed by water into sulphur and trichloride (? oxychloride) of antimony; with aqueous tartaric acid it yields a precipitate of sulphide of antimony mixed with oxide. (**Cloez**, Ann. Ch. Phys. [3] xxx. 374.)

Other sulphochlorides of antimony have been obtained by **R. Schneider** (Pogg. Ann. cviii. 407). Finely pulverised trisulphide of antimony dissolves in 14 or 15 times its weight of the melted trichloride, without evolution of sulphuretted hydrogen, and the light brown solution solidifies on cooling to a yellow crystalline mass. By pouring off the still remaining liquid at a certain stage of the solidification, the compound may be obtained in regular crystals (rhombic prisms bevelled at the ends with a macrodiagonal dome), containing $Sb^2SCl^4.6SbCl^3$. It is very deliquescent, and is decomposed by a large quantity of water, with separation of a yellow powder; by prolonged heating, it is resolved into volatile trichloride of antimony, and a black residue of sulphide. It is decomposed by absolute alcohol, out of contact of air, a large quantity of chloride of antimony and a little of the sulphide dissolving, and a reddish-yellow amorphous substance being left, containing $2SbClS.3Sb^2S^3$. This compound is decomposed, by heating in close vessels, into trichloride and trisulphide of of antimony, also by the action of dilute hydrochloric acid.

ANTIMONY, SULPHIODIDE OF. SbSI.—This compound is obtained by dissolving trisulphide of antimony in the melted tri-iodide. It has a brilliant metallic lustre and red-brown colour, appears red and transparent under the microscope, and yields a powder of a fine cherry-red colour. (**R. Schneider**, J. pr. Chem. lxxix. 422; Rép. Chim. pure, ii. 323.)

ual parts of iodine and trisulphide of antimony is slowly
losulphide, probably of the same composition, rises in red
n the receiver. The same body is formed by subliming a
ıy, 9 pts. sulphur, and 68 pts. iodine, or of 2 pts. iodine and
It forms shining transparent, blood-red needles and laminæ,
t, and sublime more easily than the iodide of antimony. It
pulsive odour. It is decomposed at a strong heat, also by
enry and Garot (J. Pharm. x. 511), assigned to this pro-
but this is doubtless incorrect.

CLES, ORGANIC. Antimony combines with alcohol-
ions, forming compounds which themselves act like simple
lorine, oxygen, sulphur, &c., in the same manner as the
ases are formed on the type of ammonia, NH^3, containing
3 at. of the alcohol-radicle; others on the type NH^4; and a
h amyl is known containing 1 at. antimony with 2 at. amyl.
f the antimony-radicles at present known, are given in the

. . . . $Sb(C^5H^{11})^2$
Triamylstibine . . . . $Sb(C^5H^{11})^3$

Triethylstibine . . . . $Sb(C^2H^5)^3$
r Tetrethylstibonium . . . $Sb(C^2H^5)^4$

r Trimethylstibine . . . $Sb(CH^3)^3$
or Tetramethylstibonium . . $Sb(CH^3)^4$

hylstibine $Sb(C^2H^5)^5$ and pentamethylstibine $Sb(CH^3)^5$, has
e by the recent experiments of Mr. Buckton (Chem. Soc.

ng 3 at. of alcohol-radicle are obtained by distilling the iodides
antimonide of potassium or sodium, or by the action of tri-
nc-ethyl. They are liquids which volatilise without decom-
o oxygen from the air, with great evolution of heat, sufficient
and methyl-compounds to produce vivid combustion. The
t. of alcohol-radicle are not known in the free state; but
by treating the corresponding compounds containing 3 at.
odides of those radicles; and these iodides when treated
water, yield the hydrated oxides of the same radicles, which
strong alkaline reaction, and uniting readily with acids like
and sodium. In this respect, they resemble the correspond
e of tetrethylium, $N(C^2H^5)^4.H.O$, &c.
ontaining 4 at. of the alcohol-radicle, are monatomic, uniting
&c.; but those which contain 3 at. alcohol-radicle, stibtri-
omic, uniting with 2 at. chlorine, iodine, &c., and with 1 at.
, $Sb(C^2H^5)^3O$, &c. The same law holds good with respect
dies similarly constituted, arsentriethyl, for example: but it
orresponding nitrogen-radicles, such as triethylamine, tri-
indeed, do not unite directly with oxygen, chlorine, iodine,
rated acids in the same manner as ammonia.

onides of Amyl, or Stibamyls.*

tained by the action of iodide of amyl on antimonide of
ng conducted similarly to that for the preparation of stib-
action has ceased, and the excess of iodide of amyl has dis-
ner distilled in an atmosphere of carbonic anhydride, whereby
aining stibdiamyl; or the product is exhausted with ether,
m ether by distillation, in which case a residue is left con-
If the stibtriamyl thus obtained is contaminated with amylic
pure compounds may be prepared from it by dissolving it in
ohol; adding alcoholic bromine till its colour just begins to
g the bromide of stibtriamyl by adding a large quantity of
mide into oxide by means of oxide of silver suspended in

Berlé, J. pr. Chem. lxv. 385; Gm. xi. 125.

alcohol; precipitating the oxide by water, and dissolving it in hydrochloric acid and alcohol; precipitating the pure chloride by another addition of water; and freeing it from a small quantity of water by heating it to 100° C. in contact with fused chloride of calcium.

Stibdiamyl. $Sb(C^5H^{11})^2 = SbAm^2$. — The distillate just mentioned, after being freed from undecomposed iodide of amyl by re-distillation over antimonide of potassium, gave off at 80° C. a colourless liquid, which burnt with a white flame, diffusing a white smoke of oxide of antimony. The liquid which then remained was stibdiamyl. It was greenish-yellow, heavier than water, and tolerably mobile, with a peculiar aromatic odour and bitter taste; insoluble in water, but miscible in all proportions with alcohol and ether. It was not spontaneously inflammable, but when set on fire, burned with a very white flame, diffusing a white fume of oxide of antimony. It exploded with great violence when heated in oxygen gas, and was decomposed by nitric acid with considerable evolution of heat. Its ethereal solution exposed to the air, left an oxide which absorbed carbonic acid; and the stibdiamyl itself heated to 100° C. in a stream of dry carbonic acid, yielded a viscid liquid, which appeared to be the carbonate $(SbAm^2)^2.CO^3$. The haloïd salts of stibdiamyl are gummy liquids; the sulphate and nitrate are precipitated from their alcoholic solutions by water, in the form of gummy masses, which dry up to amorphous solids.

Stibtriamyl or Triamylstibine. $Sb(C^5H^{11})^3 = SbAm^3$.—Transparent slightly yellowish liquid, very viscid below 20° C., more mobile at higher temperatures. It has a peculiar aromatic odour, and a bitter, somewhat metallic and very persistent taste. Specific gravity 1·333 at 17° C. (according to Cramer, Pharm. Centr. 1855, 465, it is 1·0587). In contact with the air, it does not take fire, but fumes strongly and decomposes, depositing a white powder. A drop of it placed on bibulous paper and exposed to the air, becomes so strongly heated as to char the paper. It is insoluble in water, but dissolves sparingly in alcohol, and readily in ether. It does not exhibit any tendency to unite with iodide of amyl, when heated with that compound in a sealed tube.

Stibtriamyl is a diatomic radicle, like stibtriethyl. Its *oxide*, $Sb(C^5H^{11})^3.O =$ is produced by slow evaporation of an ethereal solution of stibtriamyl in contact with the air; or by decomposing the chloride, iodide, or bromide with oxide of silver. It is a greyish-yellow viscid mass, which becomes somewhat more fluid when gently heated, but decomposes at higher temperatures. It tastes and smells like the radicle itself. It is insoluble in water, sparingly soluble in dilute alcohol and in ether, but dissolves easily in absolute alcohol. The alcoholic solution precipitates metallic oxides from their salts. Oxide of stibriamyl dissolves readily in acids, and the resulting compounds are precipitated from their solutions by water.

1. The ***chloride***, $Sb(C^5H^{11})^3Cl^2$, obtained by dissolving the oxide in hydrochloric acid, is a yellowish translucent liquid, viscid at ordinary, comparatively mobile at higher temperatures, heavier than water, soluble in alcohol and ether. It tastes and smells like stibtriamyl. Decomposes at temperatures above 160° C. The *bromide* and *iodide* resemble the chloride.

Nitrate. $Sb(C^5H^{11})^3.2NO^3$.—When the chloride or iodide is mixed with an alcoholic solution of nitrate of silver, as long as a precipitate forms, and then filtered, the filtrate forms an emulsion, from which, after standing for some time in a warm place, two liquids separate, the upper being light, yellow, and mobile, and the lower a deep brown-red oil. The upper layer, when slowly evaporated, yields the nitrate in slender white crystals grouped in stars; they may be purified by recrystallisation from dilute alcohol. The dark red oil likewise dissolves on addition of a large quantity of hydrated alcohol, and the solution, after standing for some time, yields the same crystals. These crystals melt at about 20° C.: the fused mass does not dissolve in alcohol so readily as the crystals. This salt, the only crystallisable compound of stibtriamyl, is insoluble in water and ether, but dissolves in hydrated alcohol. It has a peculiar metallic taste.

The ***sulphate***, $Sb(C^5H^{11})^3.SO^4$, is formed by decomposing equivalent quantities of sulphate of silver and a haloïd compound of stibtriamyl dissolved in alcohol. This salt was obtained only as an oily liquid body.

The white powder, formed by the action of the air upon stibtriamyl is insoluble in ether, alcohol, and water: it does not dissolve in hydrochloric acid, but imperfectly in fuming nitric acid; slowly in aqua-regia. It remains unaltered even when strongly heated, not decomposing below a red heat. Berlé supposes it to be *antimonite of stibtriamyl*, $SbAm^3O.Sb^2O^3$. When sulphuretted hydrogen was passed for some time through this compound suspended in alcohol, a white powder immediately separated, which gradually assumed an orange colour, and then formed a pulpy mass, which could not be filtered. After addition of a large quantity of alcohol and ether the liquid

ɔ stand in a warm place, deposited an orange-red, flocculent precipitate,
drying, formed a brownish-yellow powder, insoluble in alcohol, ether, and
powder decomposed at a very high temperature, and took fire when
ic acid was poured upon it. Berlé regards this compound as *sulphanti-*
tibtriamyl, $SbAm^3S.Sb^2S^3$ (it gave 18·38 per cent. sulphur, the formula
·59). A compound, supposed to be identical with this, is formed by
huretted hydrogen for some time through an alcoholic solution of oxide
yl.

Antimonides of Ethyl, or Stibethyls.

ETHYL or TRIETHYLSTIBINE, commonly called *Stibethyl*. $Sb(C^2H^5)^3 =$
wig and Schweizer, Ann. Ch. Pharm. lxxv. 315, 327; Löwig, *ibid.* lxxx.
. 79; Gerh. ii. 370.)—This compound is prepared by the action of iodide of
imonide of potassium. The alloy is finely pulverised together with two or
its weight of quartz-sand (if pulverised alone it is apt to take fire); the
ntroduced into a number of small short-necked flasks, so as to fill them to
hirds; and iodide of ethyl is added in quantity just sufficient to moisten the
lloy and sand. The action begins in a few minutes, and is accompanied with a
erature sufficient to volatilise the excess of iodide of ethyl, which is collected
a small receiver; as soon as this action is over, the flask is connected as
ossible with a condensing apparatus, through which a stream of carbonic
assed during the whole operation. This condensing apparatus consists of a
lindrical vessel closed by a cork having three apertures. Through one of
res, passes a tube proceeding from the carbonic acid apparatus, and reach-
ottom of the vessel; through the second a short straight tube to carry off
d through the third is inserted the distillation tube connected with the
ning the mixture: this tube descends nearly to the bottom of the glass
d drops into the mouth of a small receiver, partly filled with antimonide of
This apparatus being completely filled with carbonic acid gas, the gener-
s heated very gently at first, and afterwards more strongly as long as any
ls over. This flask is then removed, the distillation-tube stopped with
second flask is ready to be adapted, and the operation is then repeated.
s of 20 to 24 flasks of 3 or 4 ounces capacity yield 4 or 5 ounces of crude
ich may thus be obtained in the course of a day. The receiver in which
e has been collected is then closed while still immersed in the atmosphere
acid, afterwards removed, and used as a retort in the rectification of the
same condensing apparatus being used as before. The first portions of
product contain iodine, and deposit after a while, a number of colourless
sisting of iodide of stibethylium. (Löwig and Schweizer.)
action of trichloride of antimony on zinc-ethyl, similarly to the preparation
hosphine. (Hofmann: See PHOSPHORUS BASES.)

s. Stibtriethyl is a transparent, colourless, mobile, strongly refracting liquid,
sagreeable alliaceous odour. Specific gravity 1·3244 at 16° C. It does not
29° C. Boils at 158°·5 (bar. at 730 mm.). Vapour-density, by experi-
44; by calculation 7·18, the formula $Sb(C^2H^5)^3$, representing 2 volumes of
ibtriethyl is insoluble in water, but dissolves readily in alcohol and ether.
stibtriethyl exposed to the air at the end of a glass rod, emits thick white
in a few seconds takes fire and burns with a white, strongly luminous
en introduced in a thin stream into oxygen gas, it burns with dazzling
But if it be made to run into a glass globe containing air, in such a
not to take fire, it gives off dense white fumes, which collect on the sides of
in the form of a powder, which is insoluble in ether, but dissolves in
water; at the same time a transparent, colourless, viscid mass is formed,
luble in ether. This latter substance is the *oxide of stibtriethyl*, SbE^3O;
is *antimonite of stibtriethyl*, $SbE^3O.Sb^2O^3$. Stibtriethyl oxidises very
n immersed in water; hence it is best to keep it under that liquid. *Sul-*
ium, *iodine*, *bromine*, and *chlorine* combine directly with stibtriethyl, the
g always attended with evolution of heat, and in the case of bromine and
ith inflammation. The compounds contain 1 at. stibtriethyl, with 1 at. of
dicle, O, S, SO^4 &c., or 1 at. stibethyl with 2 at. of a monobasic radicle,
, &c., in which respect they resemble the compounds of stibtrimethyl, ar-
(see p. 322). Stibtriethyl introduced into *hydrochloric acid gas*, yields chlo-
triethyl and free hydrogen:

$$SbE^3 + 2HCl = SbE^3Cl^2 + H^2.$$

eaction takes place with fuming hydrochloric acid. Dilute *nitric acid*, with
heat, acts on stibtriethyl in the same manner as on the metals, evolving

nitric oxide and forming nitrate of stibtriethyl. Neither fuming nitric acid nor aqua-regia oxidises the antimony completely.

Antimonite of Stibtriethyl, $Sb(C^2H^5)^3.Sb^2O^4$, or $SbE^3O.Sb^2O^3$, is formed, together with the oxide, by the gradual oxidation of stibtriethyl. The white fumes which stibtriethyl diffuses in the air consist almost wholly of this compound. It may be prepared by leaving an ethereal solution of stibtriethyl to evaporate spontaneously, and dissolving out the simultaneously formed oxide with ether-alcohol. The antimonite then remains as a white, pulverulent, amorphous body. It has a bitter taste, and is soluble in water and in alcohol. The aqueous solution prepared in the cold is perfectly mobile, but when heated, becomes viscid like starch-paste, and dries up to a friable mass, having the appearance of porcelain. Water poured upon this mass dissolves the greater part, but leaves a small residue of antimonious oxide. Hydrochloric acid, added to the alcoholic solution throws down chloride of stibtriethyl; the acid liquid separated from the chloride yields with sulphuretted hydrogen, a precipitate of kermes; on mixing it with water, powder of algaroth is precipitated. (Löwig.)

Bromide of Stibtriethyl. $Sb(C^2H^5)^3Br^2$. —Stibtriethyl takes fire when added by drops to bromine. The bromide is prepared by adding a recently prepared alcoholic solution of bromine to an alcoholic solution of stibtriethyl cooled by ice, as long as the colour of the bromine disappears. On mixing the solution with a large quantity of water, the bromide of stibtriethyl is precipitated, in the form of a colourless liquid which must then be washed with water and dried by contact with chloride of calcium. Transparent, colourless, strongly refracting liquid, having a density of 1·953 at 17° C. Has an unpleasant odour like that of turpentine, and excites sneezing. Solidifies in a crystalline mass at − 10° C. It is not volatile. When distilled, it yields, among other products a strongly acid liquid having an intolerable odour like that of chloral. It is decomposed by oil of vitriol, with evolution of hydrobromic acid, and by chlorine with separation of bromine. Insoluble in water, but dissolves readily in alcohol and ether. The alcoholic solution gives with metallic salts, reactions similar to those of bromide of potassium.

Chloride of Stibtriethyl. $Sb(C^2H^5)^3Cl^2$.—Stibtriethyl dropt into chlorine gas takes fire and burns with a bright but smoky flame. Introduced into dry hydrochloric acid gas, it forms chloride of stibtriethyl, and separates a quantity of hydrogen equal in volume to half the hydrochloric acid gas. The chloride is easily obtained in the pure state by decomposing a strong solution of nitrate of stibtriethyl with strong hydrochloric acid; it then separates in the form of a liquid which may be purified in the same manner as the bromide. Transparent, colourless liquid, of specific gravity 1·540 at 17° C.; it has a powerful odour like that of turpentine, and a bitter taste. Remains fluid at 12° C. When it is distilled with water, a small portion appears to volatilise undecomposed; when heated alone, it behaves like the bromide. Strong sulphuric acid decomposes it, with evolution of hydrochloric acid, while, on the other hand, hydrochloric acid added to a solution of sulphate of stibtriethyl throws down the chloride. In other respects, its relations are like those of chloride of potassium or chloride of sodium. It is insoluble in water, but dissolves readily in alcohol and ether.

Cyanide of Stibtriethyl appears to be formed when 2 at. cyanide of mercury, and 1 at. sulphide of stibtriethyl are mixed in the state of aqueous solution. Sulphide of mercury is then formed, together with a liquid which smells like prussic acid, and behaves with metallic salts like cyanide of potassium.

Iodide of Stibtriethyl. $Sb(C^2H^5)^3I^2$.—Iodine and stibtriethyl combine together under water, with rise of temperature. On adding iodine to an ethereal solution of stibtriethyl, a violent momentary ebullition takes places, and the iodine quickly disappears. The iodide is, however, most easily prepared by adding iodine in small portions to an alcoholic solution of stibtriethyl surrounded by a frigorific mixture, as long as the colour of the iodine disappears, and leaving the colourless solution to evaporate. The iodide then crystallises in colourless needles, which must be recrystallised from alcohol, and afterwards from ether, to free them from a small quantity of adhering yellow powder.

Iodide of stibtriethyl has a slight odour of stibtriethyl and a bitter taste. It dissolves in water without decomposition and readily in alcohol and ether. It melts and solidfies at 70°·5 C., sublimes in small quantity at 100°, without alteration, but is decomposed at a somewhat higher temperature, with formation of dense white fumes. In the fused state, it is instantly decomposed by *potassium*, with separation of stibtriethyl. With *sulphuric acid* and with metallic salts, it behaves like iodide of potassium. *Hydrochloric acid* immediately precipitates chloride of stibtriethyl. *Bromine* and *chlorine* separates the iodine; so likewise does nitric acid, forming nitrate of stibtriethyl. With *zinc-ethyl* it appears to form stibpentethyl, $2SbE^3I^2 + ZnE^2 = ZnI^2 + 2SbE^5$; but this compound is decomposed by distillation into stibtriethyl, ethy-

ydride of ethyl; $Sb(C^2H^5)^5 = Sb(C^2H^5)^3 + C^2H^4 + C^2H^6$. (Buckton,
Qu. J. xiii. 116.)

de of Stibtriethyl. $(SbE^3)^2I^2O = SbE^3I^2,SbE^3O$.—Produced by the
monia on iodide of stibtriethyl:

$$2SbE^3I^2 + 2NH^3 + H^2O = (SbE^3)^2I^2O + 2NH^4I$$

ing the oxide and iodide of stibtrethyl in equivalent quantities. It forms
crystals containing 36·9 per cent. iodine: by calculation 37·1 (Strecker
harm. cvi. 306). Merck, who obtained this compound by mixing iodide of
with an ethereal solution of stibtriethyl in an atmosphere of carbonic anhy-
sed it to be, not an oxyiodide, but a monoiodide of stibtriethyl SbE^3I, and
s formation, together that with of another crystalline compound — not
t supposed to be SbE^3HI,—on the hypothesis that the iodide of stibtri-
ed by Löwig and Schweizer, really contained 1 at. hydrogen more than
sts supposed, its true formula being SbE^3HI^2, or $SbE^3I.HI$:

$$SbE^3HI^2 + SbE^3 = SbE^3I + SbE^3HI.$$

ula $SbE^3.I$ is contrary to analogy, the triethyl- and trimethyl-compounds of
uth, and phosphorus, all uniting with 2 at. I, Br or Cl. Moreover Merck's
paration, which consisted in covering the liquid with a funnel, and passing
carbonic anhydride through the beak, till all the ether was evaporated,
y well adapted to exclude the air perfectly; hence it is probable, especially
n took place but slowly, that oxide of stibtriethyl was first formed, and
ed with the iodide. The oxyiodide might, however, be formed without
r, if the mixture was not perfectly dry, the compound SbE^3HI being pro-
e same time: thus,

$$2SbE^3 + 2SbE^3I^2 + H^2O = (SbE^3)^2I^2O + 2SbE^3HI$$

odide treated with hydriodic acid yields iodide of stibtriethyl and water·

$$(SbE^3)^2I^2O + 2HI = 2SbE^3I^2 + H^2O$$

of silver, it yields oxide of stibtriethyl, SbE^3O, and with chloride of
oxychloride of stibtriethyl, $(SbE^3)^2Cl^2O$. (Strecker.)
pposed that the action of various mercury and silver-salts on his supposed
^3I, yielded a series of compounds of analogous constitution, viz. a chloride,
oxide $(SbE^3)^2O$, &c.

of Stibtriethyl. $Sb(C^2H^5)^3.2NO^3$.—Obtained by saturating dilute nitric
ide of stibtriethyl, or by dissolving stibtriethyl in the dilute acid with the
. In this latter reaction, nitric oxide is evolved, and a small quantity of
oxide separates. The salt may be obtained in crystals by evaporating the
t 62°·5 C. it melts into a transparent liquid, which solidifies to a crystal-
57°; at a higher temperature, it deflagrates like a mixture of nitre and
t dissolves easily in water, less easily in alcohol, and is nearly insoluble in
solutions have an acid reaction and bitter taste.

f Stibtriethyl. $Sb(C^2H^5)^3O$.—Formed by the direct oxidation of stibtri-
in the free state, as above mentioned, or dissolved in alcohol or ether; as
d, however, it is always more or less mixed with antimonite of stibtriethyl,
hen obtained from the ethereal solution. The alcoholic solution on the
lds but a small quantity of antimonite. Accordingly, the oxide may be
leaving a dilute alcoholic solution to evaporate slowly in a loosely covered
reating the residue with ether, which dissolves the oxide and leaves the
and repeating this treatment as long as the ether leaves any insoluble
he oxide may also be obtained by treating an aqueous solution of sulphate
yl with baryta-water; evaporating the filtrate over the water-bath; ex-
e residue with alcohol, which dissolves out a compound of oxide of stibtri-
baryta; precipitating the baryta by carbonic acid, and evaporating the
holic solution. An alcoholic solution of stibtriethyl shaken up with finely
oxide of mercury, quickly reduces the mercury to the metallic state, and
oxide of stibethyl.

stibtriethyl in its purest state, is a transparent, colourless, viscid, amorphous
dissolves readily in water and alcohol, somewhat less readily in ether;
bitter taste; does not appear to be poisonous; is not altered by exposure
is not volatile; but when heated in a tube, gives off white vapours which
bright flame, and leaves a residue containing antimony and charcoal. It
ed by *potassium*, at a gentle heat, with separation of stibtriethyl. *Fuming*
decomposes it, with evolution of light and heat; *dilute nitric* and *strong*
id dissolve it, forming salts of stibtriethyl; *hydrochloric acid* and other hy-
s dissolve it in the form of chloride of stibtriethyl and similar compounds.

Hydrosulphuric acid has no perceptible action upon it; but on evaporating a solution of the oxide saturated with the gas, crystals of sulphide of stibtriethyl are obtained; the smallest trace of antimonite of stibtriethyl mixed with the oxide is detected by the formation of a yellow precipitate.

Sulphate of Stibtriethyl, $Sb(C^2H^5)^3.SO^4$, is obtained by decomposing the aqueous solution of the sulphide with sulphate of copper. It crystallises in small white prisms, soluble in water and alcohol, inodorous, but having a bitter taste and acid reaction.

Sulphide of Stibtriethyl, $Sb(C^2H^5)^3S$, is formed, with evolution of heat, when sulphur and stibtriethyl are brought together under water. But it is most readily obtained by boiling an ethereal solution of stibtriethyl with flowers of sulphur; the liquid decanted from the sulphur soon solidifies in needle-shaped crystals, which may be purified by leaving the adhering sulphur to oxidise in the air, and crystallising several times from ether. Sulphide of stibethyl thus purified forms a bulky mass, having a silvery lustre, an unpleasant odour, and a bitter taste; it is permanent in the air when dry, melts above 100° C., and is decomposed by a stronger heat, with evolution of stibtriethyl vapour. The aqueous solution of the sulphide precipitates metals from their solutions as sulphides, and yields sulphuretted hydrogen with dilute acids.

Sulphantimonite of Stibtriethyl. $SbE^3.Sb^2S^4$, *or* $SbE^3S.Sb^2S^3$. — Sulphuretted hydrogen passed through a solution of the antimonite, throws down this compound in the form of a light yellow precipitate, having an extremely unpleasant, persistent odour, like that of mercaptan. The compound is also formed by adding recently precipitated trisulphide of antimony to a solution of sulphide of stibtriethyl, the latter being in excess, whereupon the brown-red colour of the kermes immediately changes to light yellow. Dried over sulphuric acid, it forms a powder of a beautiful light yellow colour, which changes to brown-red at the heat of the water-bath. When distilled over a spirit-lamp, it yields a liquid distillate having all the properties of sulphide of stibtriethyl. Dilute sulphuric acid poured upon it, separates trisulphide of antimony, with evolution of sulphuretted hydrogen, and formation of sulphate of stibtriethyl:

$$SbE^3.Sb^2S^4 + SO^4H^2 = SbE^3.SO^4 + H^2S + Sb^2S^3.$$

Fuming nitric acid decomposes it, with emission of light and heat.

Stibethylium. $Sb(C^2H^5)^4 = SbE^4$. (R. Löwig, J. p. Chem. lxiv. 415; Chem. Soc. Qu. J. viii. 261; Gm. x. 527.) — The iodide of this radicle is formed by introducing a mixture of equal parts of stibtriethyl and iodide of ethyl into a retort filled with carbonic acid gas, nearly filling the retort with water, sealing the neck, and then heating it in boiling water. The solution evaporated and cooled, yields beautiful hexagonal prisms, often an inch long, containing $2SbE^4I.3H^2O$, and other crystals, containing $4SbE^4I.3H^2O$. The salt has a very bitter taste, and 1 pt. of it dissolves in 5·26 pts. of water at 20° C. It dissolves more easily in absolute alcohol, but less in ether. The solution of this salt, mixed with chloride of mercury, forms a white precipitate, which dissolves in warm water, and yields crystals containing $3Hg''I^2.2SbE^4I$. Another double iodide, $3HgI^2.4SbE^4I$, is obtained by adding iodide of mercury to a hot solution of iodide of stibethylium.

The iodide digested with oxide of silver, yields a strongly alkaline solution, which when evaporated, leaves the *hydrate of stibethylium* in the form of a thick colourless oily liquid, having a strong alkaline taste and reaction. It expels ammonia from its compounds, precipitates metallic oxides, and redissolves alumina and stannic oxide. It dissolves in acids, forming salts which have a bitter taste. The *carbonate* is a tough deliquescent mass. The *sulphate* and *nitrate* crystallise. The *formate* yields needle-shaped crystals, difficult to dissolve. The *acetate* forms similar crystals, but more soluble. The *oxalate* crystallises; the succinate does not. The neutral *tartrate* and *racemate* form large deliquescent crystals; the acid tartrate, fine needles.

The *sulphide*, $(SbE^4)^2S$, is obtained by treating the oxide with hydrosulphuric acid. It is a yellowish oily liquid, soluble in water and alcohol, and exhibiting the reactions of alkaline sulphides.—The *bromide* and *chloride* are crystalline compounds obtained by saturating the oxide with the corresponding acids. The chloride forms with chloride of mercury, compounds analogous to the double iodides above mentioned. It also combines with tetrachloride of platinum, producing the compound $3PtCl^4.4SbE^4Cl$, which forms fine yellow crystals, soluble in water and alcohol.

Antimonides of Methyl.[*]

Stibtrimethyl. $Sb(CH^3)^3 = SbMe^3$.—Produced, like the corresponding ethyl-compound, by the action of iodide of methyl on antimonide of potassium. It is a colourless heavy liquid, insoluble in water, sparingly soluble in alcohol, readily in ether. When exposed to the air, it gives off thick white fumes, and takes fire, burning with a white

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[*] Laudolt, Ann. Ch. Pharm. lxxviii. 91; Gm. vii. 321; Gerh. i. 646.

ositing metallic antimony. Its compounds are precisely analogous to
ethyl.

hyl, $Sb(CH^3)^5$, appears to be produced by the action of zinc-ethyl on
and to be decomposed by distillation into stibtrimethyl and hydro-
ckton, compare page 336.)

YLIUM. $Sb(CH^3)^4 = SbMe^4$.—This compound is obtained as an iodide
f iodide of methyl on stibtrimethyl. It is not quite certain whether it has
ed. The iodide distilled with excess of antimonide of potassium, in an
carbonic anhydride, yields a spontaneously inflammable oily liquid, re-
imethyl; and the aqueous solution of the iodide subjected to the action
urrent, yields iodine at the positive pole, while at the negative pole, the
alkaline, and gives off a spontaneously inflammable gas containing
having the odour of stibtrimethyl; but which of these products, if either,
m, has not yet been ascertained.

nds of stibmethylium closely resemble the corresponding potassium-salts,
phous with them. They have a bitter taste. They are decomposed by
, and then form white fumes, if a glass rod moistened with hydro-
held over them. They are for the most part easily soluble in water,
alcohol, and insoluble in ether. The antimony in them is scarcely
y the ordinary reagents, not being precipitated by hydrosulphuric acid
time. They yield a slight deposit of antimony, when treated with
ric acid in Marsh's apparatus. They bear a heat of about 140° C. without
but between 180° and 200° they are decomposed, and give off spon-
nmable vapours.

$SbMe^4Br$.—Obtained by decomposing iodide of stibmethylium with
rcury. On filtering from the iodide of mercury and evaporating, a
is obtained, soluble in alcohol and water, but insoluble in ether, and
e bitter taste. This compound, when heated, evolves white vapours
in the air. Oil of vitriol poured upon it liberates hydrobromic acid;
rates bromine. With metallic salts, bromide of stibmethylium behaves
nner as bromide of potassium.

s.—*The neutral carbonate* is obtained by decomposing a solution of the
ently precipitated carbonate of silver. The filtered liquid evaporated
bath, leaves an indistinctly crystallised, somewhat yellowish, transparent
eliquesces very readily in the air, exhibits an alkaline reaction, dis-
sily in water and in alcohol, but very slowly in ether. This com-
unstable, beginning to smell of stibtrimethyl as soon as it is formed.
it gives off white fumes, which take fire spontaneously in the air. It
to contain water of crystallisation.—The *acid carbonate*, $(SbMe.H.)CO^3$,
passing carbonic anhydride through a solution of the oxide or of the
ate, and evaporating. It crystallises with difficulty in small deliquescent
ged in stars. In the solid form, it soon decomposes, like the neutral
e aqueous solution evolves carbonic anhydride when heated, and does
magnesium-salts.

$SbMe^4Cl$.—Obtained by adding a hot solution of corrosive sublimate to
of stibmethylium, as long as a precipitate of iodide of mercury is pro-
ltered liquid evaporated over the water-bath deposits the chloride in
tables, similar to those of the iodide. These crystals are easily soluble
lcohol, nearly insoluble in ether: their taste is saline and bitter. This
s when heated in a tube, and at a higher temperature gradually dis-
off white fumes, which take fire spontaneously in the air, and deposit
art of the tube a white sublimate containing chloride of antimony.

ate. $2(SbMe^4Cl).PtCl^4$.—Obtained as a yellow crystalline precipitate, by
loride of platinum to chloride of stibethylium. It may be dissolved in
and separates on cooling as an orange-yellow crystalline powder. It is
le in water of all the salts of stibmethylium, and is intermediate in solu-
the chloroplatinates of potassium and sodium. It is quite insoluble in
er, very difficult of solution in alkalis, but dissolves more easily in hot
cid. When heated, it turns black, and soon takes fire, leaving an alloy
d antimony, from which the latter metal is but imperfectly removed by

$SbMe^4.H.O$.—Obtained by agitating an aqueous solution of the iodide
recipitated oxide of silver, filtering from the resulting iodide of silver,
g the filtrate in vacuo over sulphuric acid. It is a white, crystalline
ls soapy between the fingers, is highly caustic, and dissolves rapidly in

water and alcohol, but is insoluble in ether. In the state of aqueous solution, it is slightly volatile, and forms white fumes when a glass rod moistened with hydrochloric acid is held over it; but the solution, when evaporated over the water-bath, yields the original quantity with scarcely any loss. When the solid hydrate is suddenly heated in a test-tube, it gives off vapours which take fire on coming in contact with the air, and deposit metallic antimony; but when carefully heated, it sublimes undecomposed.

The aqueous solution has an alkaline taste and odour, and instantly turns reddened litmus paper blue. In all its chemical relations, it exhibits the closest resemblance to caustic potash. When evaporated in an open vessel, it absorbs carbonic acid, and then effervesces strongly with acids; but on the addition of lime-water, carbonate of calcium is precipitated, and the pure base is again found in the solution. It expels *ammonia* from ammoniacal salts, even in the cold, and separates *baryta* from iodide of barium. *Lime* and *oxide of lead* are immediately precipitated by the solution of this base. With *zinc-salts* it forms a white precipitate, soluble in excess; with *copper-salts* a precipitate insoluble in excess; with *mercurous*, *mercuric*, and *silver-salts*, it gives the same reactions as potash; with *chloride of platinum*, it forms a yellow precipitate resembling the chloroplatinate of potassium. The aqueous solution, boiled with *sulphur*, forms a yellow liquid, which, when mixed with dilute acids, yields a precipitate of sulphur, and gives off sulphuretted hydrogen.

Iodide of Stibmethylium, $SbMe^4I$, is formed by the action of iodide of methyl on stibtrimethyl. If, in the preparation of stibtrimethyl, the iodide of methyl which distils over at first, and the stibtrimethyl which passes over when the temperature is raised, are collected in the same receiver, a slight ebullition takes place, and the liquid mixture solidifies after a while into a perfectly white, crystalline mass. This is dissolved in warm water, the excess of iodide of methyl separated, and the solution set aside to evaporate slowly over the water-bath. The iodide of stibmethylium then separates in crystals belonging to the hexagonal system. They are remarkably beautiful, large, six-sided tables, usually scalariform, and from 10 to 15 millimetres in diameter; the terminal faces are plane, and the lateral edges intersect one another at angles of 120°. The crystals contain water mechanically enclosed, and consequently decrepitate when heated. They dissolves in 3·3 pts. of water at 23° C., and are likewise easily soluble in alcohol, but dissolve very slowly in ether.—Iodide of stibmethylium heated in a test-tube first falls to powder, and at 200° C. begins to decompose, disappearing gradually, and evolving thick white fumes, which have the odour of stibtrimethyl. The vapour thus evolved is partly deposited as a coating on the inside of the tube; but the greater portion reaches the mouth, where it takes fire spontaneously, forming rings of smoke like phosphoretted hydrogen. Boiling water dissolves but a small portion of the deposit in the tube. The solution treated with *nitrate of silver*, yields a precipitate consisting of iodide of silver and metallic silver, the latter being doubtless produced by pure stibtrimethyl or stibmethylium, the former by undecomposed iodide. The aqueous solution of iodide of stibmethylium is gradually decomposed by repeated *evaporation*, a small quantity of a yellow insoluble substance (not yet examined) being formed, and the odour of stibtrimethyl evolved. The yellow substance likewise appears, though not constantly, when the solution is exposed to sunshine. [For the decomposition by electrolysis, see page 345.] Filtering paper, covered with strong starch-paste, to which iodide of stibmethylium has been added, behaves towards *ozone*, exactly in the same manner as paper prepared with iodide of potassium, but is even more sensitive. *Sulphuric acid*, *bromine*, *chlorine*, and *nitric acid*, act upon iodide of stibmethylium exactly as upon iodide of potassium; *hydrochloric acid* decomposes it, with formation of chloride of stibmethylium. Aqueous solution of iodide of stibmethylium poured upon *amalgam of sodium*, produces a succession of little explosions, accompanied by appearance of fire, metallic antimony being also separated. The iodide distilled with excess of *antimonide of potassium*, yields a yellow oily liquid, which is perhaps stibmethylium. The aqueous solution dissolves a considerable quantity of the yellow modification of *mercuric iodide*. The red iodide boiled in the solution changes into the yellow modification before it dissolves; and as the liquid cools, a considerable portion of the mercuric iodide separates out, but always in the yellow modification.

Nitrate of Stibmethylium, $SbMe^4.NO^3$.—Formed by adding nitrate of silver to an aqueous solution of iodide of stibmethylium as long as any precipitate is formed, then filtering and evaporating till the salt crystallises. The crystals are anhydrous. The salt dissolves readily in water, slowly in alcohol or ether. Its taste is harsh and bitter, not cooling like that of nitre. When heated, it gives off white fumes, which immediately take fire; the entire mass then explodes with a large white flame, just like a mixture of nitre and charcoal. The salt is very stable, not being decomposed, even by boiling with strong sulphuric acid.

ium.—*The neutral sulphate*, $(SbMe^4)^2.SO^4$, is obtained
hate of silver to aqueous iodide of stibmethylium, as long
ilver is formed. On evaporating the filtered liquid over
als are obtained, which may be pressed between paper and
ting a concentrated solution of the acid salt with oxide of
aqueous solution with alcohol and ether; the neutral salt
hich after a while assume the solid form. The crystals,
contain 15·42 per cent. (5 at.) water of crystallisation,
Placed over sulphuric acid, they lose part of their water,
The crystals dissolve very readily in water; the anhy-
eated when water is poured upon it. The salt is also
e in ether. Its taste is saline and bitter.
SO^4.—Obtained by adding 1 at. sulphuric acid to an
the neutral sulphate. After several crystallisations,
ystals are obtained, some of which are four-sided tablets
. It has a strongly acid taste, leaving a bitter taste in
behaves exactly like the neutral sulphate. On dissolving
, then adding alcohol, precipitating by ether, and re-
ral times, the neutral sulphate is at length obtained.
behaves exactly like acid sulphate of potassium. The
tallisation. The basic water (or hydrogen), like that of
not driven off at 120° C.

epared, like monosulphide of potassium, by dividing an
tibmethylium into two parts, saturating the one with
adding the other. The resulting solution, quickly eva-
e sulphide in the form of an amorphous green powder,
issolves readily in water and alcohol, but is insoluble in
ck precipitates with lead- and silver-salts. Heated in a
s, giving off spontaneously inflammable vapours, and
In contact with the air, it oxidises rapidly.
bmethylium boiled with sulphur, yields milk of sulphur
nce it is probable that higher sulphides of stibmethylium

UM, $Sb(CH^3)^3(C^2H^5)$, is obtained as an iodide by the action
thyl. It closely resembles the iodide of stibmethylium.

UM, $Sb(CH^3)(C^2H^5)^3 = SbMeE^3$. (Friedländer, J. pr.
0).—The *iodide* of this radicle, obtained by the action
riethyl, forms beautiful crystals, apparently having the
a glassy lustre when fresh, changing after a while to
ces when dry, but are otherwise permanent in the air.
itter taste, is inodorous when cold, but at 100° C. gives
ensible decomposition. It dissolves in twice its weight
also in alcohol, but insoluble in ether. The solutions
to the left.
ylium forms two double salts with *mercuric iodide*, viz.
dding recently precipitated mercuric iodide to a solution
ylium; and $2SbMeE^3I.3Hg''I^2$, which is precipitated on
ric chloride to a boiling solution of iodide of stibmethyl-
e antimony-radicle then remaining in solution:

$$Ig''Cl^2 = 2SbMeE^3I.3Hg''I^2 + 6SbMeE^3Cl.$$

le in water; and sparingly soluble in alcohol and ether,
c solution in yellow needles which melt below 100° C.
uced as above, or by dissolving the hydrate or carbonate
be obtained by evaporation in small crystalline needles.
decomposing the iodide with moist oxide of silver (when
ays contains silver); or (2), by decomposing the sul-
ent quantity of hydrate of barium, and concentrating the
ck, oily, non-volatile liquid, which has a strong bitter
composes ammonia-salts, and precipitates metallic oxides
and alumina precipitates being soluble in excess.
ylium dissolves in acids, forming neutral and acid salts,
ed by double decomposition from the iodide, chloride, or
or less soluble in water and alcohol; some are deliques-
ose which crystallise do not contain water. There are
ethylium.

The *carbonate*, $(SbMeE^3)^2.CO^3$, is a white resinous mass which reacts like carbonate of ammonium. The *sulphate*, $(SbMeE^3)^2.SO^4$ is produced by dissolving the hydrate in sulphuric acid, or by decomposing the iodide with sulphide of silver, and may be obtained, by evaporation in vacuo, in white, shining, bitter crystals, which melt at 100° C. and are extremely deliquescent.

The *acetate*, *formate*, and *butyrate* are crystalline. The *neutral oxalate*, $(SbMeE^3)^2.C^2O^4$, forms anhydrous glassy needles, moderately soluble in water. The *acid oxalate*, $SbMeE^3.H.C^2O^4$, forms needles very soluble in water. The *tartrate* is obtained by evaporation as a syrupy liquid which rapidly absorbs water, but does not crystallise.

The *cyanide* is obtained by dissolving the hydrate in hydrocyanic acid. The clear watery solution boiled with potash-ley gives off ammonia and forms an antimonetted acid, which yields insoluble or sparingly soluble salts with all bases, except potash, soda, and ammonia.

ANTIPHLOGISTIC THEORY. See COMBUSTION.

ANTIRRHIN. See ANTHOKIRRIN.

ANTIRRHINIC ACID. An acid of unknown composition, obtained by Morin from the leaves of the fox-glove (*Digitalis purpurea*). It is prepared by distilling the leaves with water, saturating the distillate with baryta, evaporating, distilling the residue with excess of sulphuric or oxalic acid, and rectifying over chloride of calcium. The acid then floats on the top of the liquid in oily drops, having an unpleasant odour like that of the plant, and producing headache and giddiness. It reddens litmus strongly, dissolves readily in alcohol, and in contact with water forms white films, which gradually dissolve. (J. Pharm. April 1845, p. 299.)

ANTISEPTICS. Substances which prevent the spontaneous decomposition of vegetable and animal substances. They are chiefly: the mineral acids, the alkaline hypochlorites, common salt, nitre, spices, sugar, creosote and yeast. (See FERMENTATION and PUTREFACTION.)

ANTITARTARIC ACID, also called *Lævotartaric* and *Lævoracemic* acid. Pasteur has shown that racemic acid, which has no action on polarised light, is a compound of two acids in equal proportions, one of which turns the plane of polarisation of a ray of light to the right, and the other to the left. Hence he calls these acids respectively, *dextro-* and *lævoracemic acids*, or *dextro-* and *lævo-tartaric*. The dextro-acid is identical with ordinary tartaric acid. Gmelin (Handb. x. 365) retains the name *tartaric* for the ordinary dextro-rotatory acid, and distinguishes the lævo-rotating acid as antitartaric acid. (See TARTARIC and RACEMIC ACIDS.)

ANTRIMOLITE. A hydrated silicate of aluminium, found in white stalactitic masses on the north coast of Antrim. According to Th. Thompson's analysis (J. pr. Chem. viii. 489) it contains 43·47 per cent. of silica, 30·26 alumina, and 15·32 water, together with 7·50 per cent. lime. 4·10 potash, 0·19 protoxide of iron, and 0·09 chlorine. It appears to be related to mesotype.

ANTS, OIL OF. The red ant (*Formica rufa*) contains a volatile oil, which may be extracted by distilling the insects with water: to the amount of 0·12 per cent., according to Nölle; 1 per cent. according to Hermbstadt. It is transparent and colourless, and has an agreeable odour; its taste is not burning. It is slightly soluble in absolute alcohol. (Gm. xiv. 358.)

ANTYRRHINIC ACID. The name given by Walz to a volatile acid, obtained by distilling toad-flax (*Antirrhinum Linaria*, L., *Linaria vulgaris*, Dec.) with water. It forms a deliquescent barium-salt, the analysis of which gives for the atomic weight of the acid the number 212.

ANYLAMIDE. Syn. with Nitrosalicylamide. See SALICYLAMIDE.

APATELITE. A native basic sesquisulphate of iron = $2(Fe^2O^3.3SO^3) + 3H^2O$, found, in egg-shaped, earthy, yellow masses, in the clay, at Meudon and Auteuil, near Paris.

APATITE. *Phosphate of calcium.* — This mineral occurs both massive and crystallised. The crystals are six-sided prisms, belonging to the rhombohedral system, sometimes passing into the six-sided table; often hemihedral. Lustre vitreous, inclining to subresinous. Translucent, rarely transparent. Scratches fluor-spar, but is scratched by felspar. Brittle. Colours, white, wine-yellow, green, and red. Specific gravity 3·17 to 3·25. Phosphoresces on coals. Electric by heat and friction. It occurs in primitive rocks; in the tin veins of the granite of St. Michael's Mount, Cornwall; near Chudleigh in Devonshire; at Nantes in France; on the St. Gothard; and with molybdenum in granite, near Colbeck, Cumberland; also at Ehrenfrie-

axony, in the Tyrol, in Bavaria, in Bohemia, and in Spain. Large
und near New York — one crystal from Robinson's farm being nearly a
and weighing 18 pounds — also in New Hampshire, in Maine, Massa-
elaware. A massive variety called *Phosphorite*, because it becomes phos-
friction, is found in veins of tin-stone, and likewise in secondary forma-
large vein of this mineral is found at Estremadura in Spain. It has a
kidney-shaped surface, and a radiating fibrous texture.
l composition of apatite may be expressed, according to Gustav Rose
. 185), by the general formula, $3P^2O^8Ca^3 + \genfrac{}{}{0pt}{}{Ca''F^2}{Ca''Cl^2}$, the chlorine and
are isomorphous, being capable of replacing one another in any pro-
ver. If the chlorine is altogether absent, the mineral becomes a *Fluor-*
ncolite, $3P^2O^8Ca^3 + CaF^2$, containing 7·9 per cent. fluoride of calcium,
asic phosphate. An analysis of Francolite by Dr. Henry gives in 100
phoric anhydride (P^2O^5), 53·38 lime (CaO), 2·96 protoxide of iron (FeO),
nd a trace of chlorine; whence we may calculate that the proportion
sphate of calcium is 93·3, and that of the fluoride 4·91; part of the
ntity of calcium is, however, replaced by the iron. The apatites of the St.
renfriedersdorf in Saxony, and of Faldigl and Greiner in the Tyrol, are
Apatites free from fluorine have not yet been found. The greater num-
orine and fluorine together. The largest amount of chloride of calcium
apatite of Snarum in Norway, which contains 4·28 $CaCl^2$, 1·59 CaF^2,
Ca^3. An apatite in which the fluorine was wholly replaced by chlorine
10·62 per cent. of chloride of calcium.
ition of apatite is only a particular case of the general formula
$+ \genfrac{}{}{0pt}{}{M''Cl^2}{M''F^2}$, in which M″ denotes a metal, which, in the species hitherto exa-
either calcium or lead, and in which phosphorus and arsenic may
her in any proportion, as well as chlorine and fluorine. This formula
les the pyromorphites, or green lead-ores, which are isomorphous with
ite was so named by Werner from ἀπατεῖν, to deceive, on account of the
e earlier mineralogists respecting its nature. (Handw. d. Chem. 2^te

. A mineral free from phosphoric acid, found in certain American

ACID. See Azelaic Acid.

BITE. See Abichite (p. 6).

TE. See Diorite.

STIC LAMP. Lamp without flame, or glow-lamp. (See Alcohol,

. *Schieferspar. Chaux carbonatée nacrée.* — A slaty carbonate of
g a mother-of-pearl lustre, found rarely in beds and veins in the older
rnwall, at Kongsberg, &c. A soft friable variety of it, called *earth-foam*
Schaumerde), containing silica and oxide of iron, is found at Gera, and
Thuringia.

TE. See Tourmaline.

ITE. A hydrated silicate of magnesium, resembling meerschaum,
gbanshytta, in Sweden. Its formula is $16MgO.15SiO^2 + 12H^2O$.
gnesia-silicates, 3 at. water may be supposed to replace 1 at. magnesia
), hence the preceding formula may be reduced to $4MO.3SiO^2$ [M
tomic metal].

ITRUM, (ἄφρος froth and νίτρον soda.) — An old name for the saline
formed on walls, commonly called *wall-nitre*, but consisting for the most
ate and sulphate of sodium, sometimes with sulphate of magnesium.

IDERITE. A silicate of iron and aluminium, containing, according to
6·4 per cent. silica, 21·2 alumina, 1·1 magnesia, 44·2 protoxide of iron,
ter. Sandberger represents it by the formula $3(3FeO.SiO^3) +$
$6HO$. It is doubtful, however, whether all the iron exists as protoxide.

OSE. See Arcanite.

ITE. The name given by Svanberg to a mineral from Wärmkog, in
sembling fahl-ore (*q. v.*), but distinguished by a peculiarly large amount
lic sulphides. According to Svanberg's analysis (Ofversigt af Kongl.

Vätenskaps Acad. Vörhandlingar, iv. 85), its general formula is $7M^2S.Sb^2S^3$; perhap mixture of $6M^2S.Sb^2S^3$ with M^2S. It consists chiefly of copper, zinc, silver, iron, a antimony, with only a trace of arsenic. Specific gravity 4·87.

APIIN.—A gelatinous substance extracted by Braconnot (Ann. Ch. Phys. [ix. 250), from common parsley (*Apium petroselinum*) by boiling with water. T boiling liquor passed through a cloth becomes on cooling a transparent jelly, li pectic acid. It is washed in cold water, and after drying over the water-bath. treated with boiling alcohol and ether, which extract from it a certain quantity chlorophyll.

Pure apiin is a colourless powder, without odour or taste. It melts at 180° C. in a yellow liquid, which forms a vitreous mass on cooling. It begins to decomp between 200° and 210° C. It is very sparingly soluble in cold water, but dissolves read in boiling water, which deposits it on cooling in the form of a jelly. It is solu in boiling alcohol and insoluble in ether. According to Planta and Wallace (An Ch. Pharm. lxxiv. 262) it contains $C^{24}H^{28}O^{13}$. Its solution in boiling water produ a blood-red colour with ferrous salts: this reaction is extremely delicate, sufficing indicate the smallest traces of apiin. The aqueous solution, after boiling for a lo time, no longer gelatinises on cooling, but deposits nearly white flakes, which app to consist of $C^{24}H^{28}O^{13}.H^2O$. When apiin is boiled with dilute sulphuric or h drochloric acid, the liquor deposits on cooling, white flakes, which appear to conta $C^{24}H^{20}O^9$, that is to say, apiin *minus* 4 atoms of water. Apiin is dissolved alkalis and reprecipitated in its original state by acids. When boiled with su phuric acid and peroxide of manganese, it yields carbonic, acetic, and formic acids.

APIOS TUBEROSA or *Glycine apios* (*L.*)—A leguminous plant from Nor America, the roots of which have been proposed as a substitute for the potato, and t young seeds for peas. The roots are eaten in Virginia, and are said to have been us by the aborigines of the country. Payen (Compt. rend. xxviii. 189) gives the follo ing statement of the composition of the roots, compared with that of the variety potato called *patraque jaune:*

	Apios.	Potato.
Nitrogenous matter	4·5	1·7
Fatty matter	0·8	0·1
Starch, sugar, pectin, &c.	33·55	21·2
Cellulose and epidermis	1·3	1·5
Inorganic matter	2·25	1·1
Water	57·8	74·4

APIRIN or **APYRIN.** An alkaline substance said to be contained in the n of *Cocos nucifera* and *Cocos lapidea.* (Bizio, J. Chim. méd. 1833, 495.)

APJOHNITE. See MANGANESE-ALUM.

APLITE. A name inappropriately given to a kind of granite, consisting chie of a fine-ground mixture of quartz and felspar with only a trace of mica.

APLOME. See GARNET. — **APOGLUCIC ACID.** See GLUCIC ACID.

APROCRENIC ACID. See HUMIC ACID.

APOPHYLLIC ACID, $C^8H^7NO^4$.—A nitrogenous acid obtained by the d composition of cotarnine; first prepared by Wöhler (Ann. Ch. Pharm. i. 24), afte wards more fully examined by Anderson (Edinb. Phil. Trans. xxiii. 347; Chem. So Qu. J. v. 257).

Preparation.—1. Cotarnine is dissolved in nitric acid diluted with twice its volum of water; strong nitric acid is added; and the whole is heated to boiling, whereup abundance of red vapours are evolved. As soon as a small portion of the solution, o being mixed with alcohol and ether, quickly deposits crystals (if no crystals appe the heating must be continued), the whole of the solution is treated in the same wa and the crystals which are deposited after 24 hours, are filtered off and purified b boiling their solution which animal charcoal, and recrystallising. A great excess o nitric acid hinders the precipitation of the apophyllic acid (Anderson).—2. O decomposing chloroplatinate of cotarnine with sulphuretted hydrogen, filtering o the platinum and evaporating the filtrate with hydrate of barium, apophyllate of bariu was found in the residue; and after extracting the cotarnine with alcohol, and boilin the residue with dilute sulphuric acid, a yellow solution was obtained which deposite crystals of apophyllic acid after the lapse of several weeks. (Wöhler.)

Apophyllic acid crystallises from a boiling saturated solution on cooling, in rathe long anhydrous prisms, which do not effloresce when heated. It reddens litmus strong and has a weak acid taste (Wöhler). Melts at 205° C., and solidifies on coolin into a crystalline mass. (Anderson.)

l apophyllic acid, $C^8H^7NO^4.H^2O$, crystallises from a saturated and not
on, in colourless, very sharp rhombic octahedrons the form of which
that of a square-based octahedron. Angles of the base about 88° and
eral edges, about 106° 28′, 105° 24′, and 190°. The crystals cleave very
irection parallel to the base, forming faces of pearly lustre, like the
phyllite (hence the name). These give off their water, amounting to
nt., at a temperature much below 100° C. (Wöhler.)
ophyllic Acid.—Apophyllic acid dissolves slowly and with great difficulty
It is soluble in sulphuric acid (Anderson); insoluble in alcohol and

ed, it melts, chars, and evolves an oily, strongly alkaline liquid, which
noline (Wöhler). By distillation it yields a neutral oil, as well as a base,
t become coloured when treated with chloride of lime (Anderson).—
converts it into oxalic acid (Anderson).

tes.—Nearly all the apophyllates are soluble in water.
of Ammonium forms small prismatic needles. It is readily soluble in

of Barium is obtained in nodular crystals by digesting the acid with
arium and adding alcohol to the solution. (Anderson.)
of Ammonium does not precipitate *lead-salts*. (Wöhler.)
of Silver, $C^8H^6AgNO^4$, is obtained by digesting apophyllic acid with
e of silver and precipitating the solution with alcohol and ether. It
alline powder, which burns slowly when heated, leaving a residue of
. It is easily soluble in water, insoluble in alcohol and ether (Ander-
xing a solution of apophyllate of ammonium with nitrate of silver,
consisting of apophyllate and nitrate of silver, $C^8H^6AgNO^4.NO^3Ag$, is
r a while in small crystalline stars, which soon increase to zeolitic
needles. The salt explodes violently when heated, like oxalate of silver.
oluble in water.

LLITE. *Ichthyophthalmite, Fish-eye stone.*—A silicate of calcium and
o containing fluorine, which is found both massive and crystallised.
elong to the dimetric system. The most usual form is ∞ P ∞ . P, also
vage perfect, parallel to 0P, imperfect parallel to ∞ P ∞. The massive
laminated structure. Specific gravity 2·3 to 2·4. Hardness about that
generally rather less. The finest varieties are transparent and colour-
mes tinged with rose colour; translucent crystals are also found, or
mass, translucent only at the edges, and white, reddish-white, or flesh-
ternal lustre splendent and peculiar; internal lustre glistening and
transparent crystals exhibit, according to Brewster, a peculiar optical
ch shows that each individual crystal is an aggregate of several pieces
arranged. In some places (especially at Aussig in Bohemia) a variety
ound, consisting of opaque crystals of peculiar form. Apophyllite, heated
vpipe, exfoliates (hence its name, from ἀποφυλλίζειν), then froths, and
opaque bead. It is easily decomposed by strong hydrochloric acid, with
gelatinous silica. The filtrate, supersaturated with ammonia, yields
f fluoride of calcium.
ition of apophyllite, as determined by analysis, is as follows:—

	Berzelius.	Stromeyer.	C. Gmelin.
ica	52·13	51·86	53·90
tash	5·27	5·31	6·13
me (including CaF^2) . .	25·53	25·22	25·00
ater	16·20	16·91	15·70
	99·13	99·30	100·73

results, L. Gmelin (Handb. iii. 394) deduces the formula $KO.2SiO^2$
$+ CaO.SiO^2 + CaF + 16HO$*, or $15SiO^2.7CaO.K^2O + CaF^2 + 16H^2O$.†
le may be obtained, if we suppose the fluorine to take the place of
ygen in equivalent proportion. Berzelius gives the formula $KO.2SiO^3$
)‡ $+ 16HO$, which, if M denote a monatomic radicle, may be reduced to
$6HO$. The analytical results may, however, be equally well represented
l formula $9SiO^3.8MO.15HO$; and, assuming that $3HO$ may replace
IORPHISM, POLYMERIC), this formula may be reduced to $9SiO^3.13MO$,‡
O.

14; O = 8. † Si = 28; O = 16. ‡ Si = 21·3; O = 8.

APORETIN. A resin obtained by dissolving in alcohol that portion of th alcoholic extract of rhubarb which is insoluble in water, precipitating by ether, a again treating the precipitate with alcohol, the aporetin then remaining undissolv (Schlossberger and Döpping, Ann. Ch. Pharm. i. 219). Treated with conce trated nitric acid, it yields a yellow substance, which appears to be chrysammic ac together with oxalic acid and an acid which produces a brown-red colouring wit alkalis. (De la Rue and Müller, Chem. Soc. Qu. J. x. 298.)

APOSEPIDIN. *Käsoxyd.*—A product of the putrefaction of the so-calle protein-compounds, discovered by Proust, but since shown by Mulder and others to merely impure leucine.

APOTHEM. A term applied by Berzelius to the insoluble brown deposit whic forms in vegetable extracts when exposed to the air. It is not a definite compoun but a mixture of several substances in a state of decomposition, and therefore of ver variable constitution. (See Decay and Putrefaction.)

APPLES. A comparison of various sorts of apples and pears, with regard specific gravity and amount of water and acid in the juice, has been made by Schulz (J. pr. Chem. lxii. 207). The results vary greatly according to season, climate, an soil; but the general conclusions are as follows:—The specific gravity of the fres fruit varies from 0·72 to 0·91. The fruits contain between 13 and 21 per cent. of dr substance, of specific gravity above 1·4. The juice of 20 kinds of apples had a specif gravity between 1·020 and 1·027; in two varieties only, it was found to be betwee 1·033 and 1·037. The acid in the juice, estimated as tartaric acid, amounted between 0·48 and 1·13 per cent. In Wurtemberg. the specific gravity of the juice apples and pears rises in warm seasons above 1·080, and even approaches 1·090, th amount of free acid, estimated as tartaric acid, varying from 0·4 to 1·2 per cent., an that of sugar from 4 to 10 per cent.

APPLE-TREE. (*Pyrus Malus.*)—The ash of the branch of an apple-tree con tained, after deducting the carbonic acid, in 100 pts.: 19·24 potash; 0·45 soda 63·60 lime; 7·46 magnesia; 2·41 ferric phosphate; 4·15 phosphoric acid; 0·45 chlo ride of sodium; 0·93 sulphuric acid; and 1·31 silica. (Fresenius, Handw. d. Chem 2te Aufl. i. 171.)

APPLE-OIL. *Maloïle.*—A yellowish oil formed in apples when kept. It lighter than water, has a yellowish-grey colour, a sharp and harsh taste, boils 190° C., and distils completely; burns with a slightly fuliginous flame; dissolve sparingly in water, but readily in alcohol and ether. Contains 64·15 per cent. carbon 20·65 hydrogen, and 15·20 oxygen. Forms a crystalline compound with hydrochlori acid, but is decomposed by chlorine. (Handw. d. Chem. 2te Aufl. i. 172.)

APPLE-OIL (ARTIFICIAL). This name is given to a solution of valerat of amyl in 6 or 7 parts of alcohol, which has the smell of apples, and is used as perfume. (Hofmann, Ann. Ch. Pharm. lxxxi. 87.)

APYRIN. See Apirin.

APYRITE. *Siberite, Rubellite, Red tourmaline.* See Tourmaline.

AQUA FORTIS. This name is given to a weak and impure nitric acid commonly used in the arts. It is distinguished by the terms *double* and *single*, the single having only half the strength of the other. The artists who use these acids call the more concentrated acid, which is much stronger even than the double aqua fortis, *spirit of nitre.* (See Nitric Acid.)

AQUAMARINE. See Beryl.

AQUA-REGIA or **REGIS.** A mixture of nitric and hydrochloric acid, called from its property of dissolving the noble metals, gold and platinum. (See Nitro-hydrochloric Acid).

AQUA-VITÆ. Ardent spirit of the first distillation has been distinguished by this name in commerce. The distillers of malt and molasses spirits call it *low wines.*

AQUILA ALBA, MITIGATA, CŒLESTIS, MERCURII. An old name for subchloride of mercury; also *mercurius dulcis*, or *mild muriate of mercury.*

ARABIC (GUM). This gum exudes spontaneously from several species of acacia (*Acacia vera, A. arabica*) &c. It was formerly imported into Europe from Egypt and Arabia, but is now obtained chiefly from Senegal. The coarser and cheaper varieties mostly used by calico printers and other manufacturers are known by the name of gum-senegal. (See Gum.)

ARABIN. The principal constituent of gum arabic, in which, according to

. cii. 105), it exists in combination with lime, magnesia
gum with hydrochloric acid and alcohol, these compounds
in is separated in the form of a gum, which exhibits the
moist state, it dissolves readily in cold water, forming a
t is precipitated by alcohol. After drying at 100° C. it no
, but merely swells up to a gelatinous mass. Dried at
on $C^{12}H^{22}O^{11}$, $\frac{1}{11}$ of the hydrogen being replaceable by

$^{20}H^{40}O^2 = \left.\begin{matrix}C^{20}H^{39}O\\ H\end{matrix}\right\}O$. — Produced by the saponification
pogæa). The oil is saponified with soda; the mixture of
soap by hydrochloric acid, is macerated with five or six
l to remove the volatile acids; the insoluble portions
alcohol; and the solution, heated nearly to the boiling
uantity of acetic acid, that on adding an excess of alco-
pitation takes place while the liquid remains hot. The
he liquid has remained in the cold for forty-eight hours,
d and mixed with alcohol and hydrochloric acid; the
acids, after being filtered off from the chloride of lead
ol by evaporation, are decomposed by boiling with soda-ley
pletely expelled; the resulting soda-soap is decomposed
mixture of fatty acids thus separated, is again dissolved
recipitated with alcoholic acetate of magnesium. The
tain arachidic acid, which after several crystallisations is

very small shining scales; melts at 75° C., and solidifies
iated mass, which after a while assumes the appearance
slightly soluble in cold alcohol of ordinary strength, but
solute alcohol and in ether. (A. Gössmann, Ann. Ch.

nging in fact to the series of fatty acids, $C^nH^{2n-1}O^2.H$.
nd sodium salts, are soluble in water, the rest insoluble
er, but soluble in boiling alcohol. The silver-salt,
pitate which separates from boiling alcohol in slightly
y exposure to light. (Gössmann and Scheven, Ann.

$I^{39}O^2.C^2H^3$, obtained by passing hydrochloric acid gas
of the acid at 80° or 90° C., is a crystalline, slightly
t 52·5°, and solidifies at 51°. (Gössmann.)

N, is obtained by leaving earth-nut oil for several
a. It forms prisms grouped in stars, insoluble in water,
lity in boiling alcohol, melting at 98° or 99° C. When
m, it gives off ammonia.

lyceryl, is obtained by heating equal parts of arachidic
10° C. in a sealed tube. It is a lustrous fatty substance
lidifies in a crystalline mass when slowly cooled. It dis-
90 per cent., more freely in absolute alcohol, and still
alysis 76·2 per cent. carbon, and 12·6 hydrogen; whereas
glyceryl, $C^3H^5O^3.(C^{20}H^{39}O)^3$, requires 77·62 C and 12·6 H
Berthelot (Ann. Ch. Phys. [3] xlvii. 355) regards the
ann and Scheven as a mixture of diarachin with free
the pure neutral arachins by melting in a flask the crude
lycerin with arachidic acid, then adding slaked lime to
gesting with ether for fifteen minutes, and afterwards
lves the neutral fat and leaves the lime-soap undissolved.
evaporated, leaves the neutral fat, which, if quite free
uld form with boiling alcohol a solution which does not
ner Berthelot has obtained the three neutral arachins,
ns, viz. *monoarachin*, $C^3H^5O^3.C^{20}H^{39}O.H^2$, *diarachin*,
rachin, $C^3H^5O^3.(C^{20}H^{39}O)^3$.

. *Earth-nut.* — A leguminous creeping plant, indi-
s of South Africa and South America, and cultivated in
outh of Europe. The flower-bearing stems exhibit, as
form, a tendency to bury themselves in the soil, those
earing little or no fruit. Hence in the cultivation of the
tended to is to cover up with earth all the flower-bearing

stems as soon as the flowers fade. The seeds contain about half their weight of fa oil, *earth-nut oil* (*huile d'arachide, huile de pistache de terre, Erdnuss-öl*), which i extracted from them by pressure. The cold-pressed oil is nearly colourless, has faint agreeable odour, and may be used for culinary purposes instead of olive oi only it becomes rancid more quickly. The warm-pressed oil is coloured, and ha a disagreeable taste and smell. The cold-pressed oil has a density of 0·916 at 50° C. and solidifies at – 3° C. When it is exposed for some time to a temperature of + 3° a solid fat resembling stearin separates from it. It dissolves but sparingly in alcoho more readily in ether and essential oils. It saponifies slowly when boiled with caust soda, yielding a hard, white, odourless soap, which is manufactured in France, and t some extent also in Germany. This soap, when decomposed by the stronger acids yields two peculiar fat-acids, viz. arachidic acid, $C^{20}H^{40}O^2$, belonging to the seri $C^nH^{2n}O^2$, and hypogæic acid, $C^{16}H^{30}O^2$, belonging to the oleic acid series, C^nH^{2n-2} besides a large quantity of palmitic acid. The oil consists therefore of arachin, hypogæin, and palmitin.

ARACHYL. $C^{20}H^{39}O$.—The hypothetical radicle of arachidic acid.

ARÆOMETER. See HYDROMETER.

ARÆOXENE (from ἄραιος, rare and ξένος, guest). — A variety of vanadate o lead, in which a considerable portion of the lead is replaced by zinc, giving th formula $3(Pb\,;Zn)''O.V^2O^5$. Von Kobell found 48·7 per cent. oxide of lead, and 16·3 p cent. oxide of zinc. The mineral, which was formerly mistaken for chromate of lea is found in clefts of a bed of sandstone, at Dahn in the Rheinpfalz. It form botryoïdal crystalline masses, exhibiting on the fracture traces of radiating structure Colour, dark red, inclining to brown; slightly translucent. Streak, light yellow Hardness 3. Melts quickly before the blowpipe, with intumescence. The powde is easily decomposed by heating with hydrochloric acid. (See Kobell, J. pr. Chem ii. 496.)

ARBOL-A-BREA RESIN. This resin is the produce of the *Canarium albu* a tree belonging to the natural order *Terebinthaceæ*, which grows in the Phillipin Islands; the resin, which is used by the natives for caulking their canoes, is greyis yellow, soft, glutinous, and has a strong agreeable odour. According to Bonastr (J. Pharm. x. 199) it contains in 100 pts. 61·29 pts. of resin, very soluble in alcohol 25·00 of resin, sparingly soluble in alcohol; 6·25 essential oil; 0·52 free acid; 0·5 bitter extractive matter; 6·42 woody and earthy impurities. Baup (Ann. Ch. Phys [3] xxxi. 108) has obtained from it four different crystallisable substances, viz.—

Amyrin.—Insoluble in water, sparingly soluble in cold, easily in hot alcohol, easil also in ether, whence it crystallises in satiny fibres, having a strong lustre. Melts a 174° C. Contains, according to Dumas, 85·3 per cent. carbon and 11·7 hydrogen, an is perhaps identical with crystallised elemi-resin.

Breïdin.—Crystallises in transparent rhomboïdal prisms of 102° and 78°, terminate by four sided pyramids. Dissolves in 260 pts. of water at 10° C. much more abun dantly in hot water; easily in alcohol, sparingly in ether,. The crystals becom opaque at a gentle heat, melt at a temperature a little above that of boiling wate and sublime undecomposed at a higher temperature, yielding a slightly pungen vapour which excites coughing.

Breïn.—Insoluble in water, soluble in 70 pts. of 85 per cent. alcohol at 20° C.; mor soluble in absolute alcohol; very soluble in ether. When slowly crystallised from an alcoholic solution, it forms transparent rhomboïdal prisms of about 70° and 110° terminated by dihedral summits whose faces meet at about 80°. By rapid coolin acicular crystals are formed. Melts at 187° C. Neutral.

Bryoïdin.—Crystallises from water in white silky filaments. Has a slightly bitte and burning taste, and when heated gives off a vapour which excites coughing. Melt at 135° C., begins to volatilise before melting, and sublimes in colourless needles. Spar ingly soluble in cold, much more in hot water, very easily in alcohol and ether. Th aqueous solution is neutral to test-paper, but precipitates acetate and subacetat of lead.

ARBOR DIANÆ, ARBOR MARTIS, ARBOR SATURNI, &c. Thes names are applied to the arborescent metallic precipitates formed by the slow reductio of one metal in solution by another, *e.g.* lead by zinc.

ARBUTIN. A crystalline substance discovered by Kawalier (Ann. Ch. Pharm lxxxi. 241; lxxxiv. 356) in the leaves of the red bear-berry (*Arctostaphylos Ur Ursi*). The aqueous infusion of the leaves forms with neutral acetate of lead yellow precipitate containing gallic acid; the filtered liquid freed from excess o lead by hydrosulphuric acid, and then concentrated to the consistence of a syrup deposits crystals of arbutin, which may be purified by pressure, solution in boilin reatment with animal charcoal. Arbutin forms groups of colourless , which are soluble in water, alcohol, and ether; the solutions are neutrai

ed it melts and gives off water of crytallisation. Its aqueous solution any precipitate with ferric salts, or with acetate or subacetate of lead. of arbutin mixed with emulsin (extracted from sweet-almonds), and left in a warm place, acquires a reddish tint, and leaves when evaporated er-bath, a reddish brown residue, from which ether extracts arctuvin, quantity of insoluble saccharine matters. This decomposition of arbutin l, according to Kawalier, by the equation:

$$\underset{\text{Arbutin.}}{C^{32}H^{44}O^{19}} = \underset{\text{Arctuvin.}}{C^{20}H^{20}O^{7}} + \underset{\text{Glucose.}}{C^{12}H^{24}O^{12}}$$

to Gerhardt, by the equation

$$\underset{\text{Arbutin.}}{C^{18}H^{22}O^{10}} = \underset{\text{Arctuvin.}}{C^{12}H^{16}O^{4}} + \underset{\text{Glucose.}}{C^{6}H^{12}O^{6}}$$

nalysis of arbutin gives 52·4 per cent. carbon, and 6·1 hydrogen. Hu res 52·4 C and 6·0 H; Gerhardt's, 54·2 C and 5·5 H. (Gerhardt, Traité,

TE. See GLASERITE.

, ORCHIL, or **ORSEILLE.** A fine purple dye obtained from various en. There are two varieties, called in France *orseille de mer* and *orseille* former is obtained from various lichens of the genus *Rocella* growing on sts of the Azores, the Canary and Cape de Verd isles, also of the Cape , Madeira, Corsica, Sardinia, &c.; the latter from *Variolaria orcina*, from *riolaria dealbata*, from the Pyrenees, *Lecanora tartarea*, from Sweden, and of these lichens contain the colouring matter ready formed, but they in colourless acids, *erythric*, *lecanoric acid*, &c., which are susceptible tion into a colourless neutral body called *orcin* (*q.v.*); and this, when by the air and by ammonia, changes into a purple substance called is the colouring principle of archil.

archil, the lichens, after being ground between stones, are rubbed up to with water and putrefied urine or carbonate of ammonium, and left to addition of quick lime, a small quantity of alum or arsenious acid being led, perhaps, to prevent the fermentation from going too far. In a week, r is obtained, which becomes brighter in a few days longer. When potassium or sodium is added to the lichens as well as ammonia, a ge takes place, and a blue colouring matter called *Litmus* is obtained, r produced by the action of ammonia alone. (See LITMUS.)

y employ archil by itself, on account of its dearness, and the perishable- eauty. The chief use they make of it is for giving a bloom to other nks, &c. This is effected by passing the dyed cloth or silk through hot y impregnated with the archil. The bloom thus communicated soon exposure to the air. The addition of a little solution of tin gives a the colour of the archil being at the same time changed toward a scarlet, more permanent in proportion as it recedes the more from the natural

rchil very readily gives out its colour to water and to alcohol; it is the incipally made use of for colouring the spirits of thermometers. As the air destroys its colour upon cloth, so does the exclusion of the like effect in these hermetically sealed tubes, the spirits of large ther- coming in a few years colourless. The Abbé Nollet observes (in the he Académie des Sciences for the year 1742) that the colourless spirit, the tube, soon resumes its colour, and this for a number of times succes- a watery tincture of archil, included in the tubes of thermometers, lost its ee days; and that in an open deep vessel it became colourless at the the upper retained its colour.

of archil in water, applied on cold marble, stains it of a beautiful violet lue colour, far more durable than the colour which it communicates to M. du Fay says he has seen pieces of marble stained with it, which in l suffered no sensible change. It sinks deep into the marble, sometimes h, and at the same time spreads upon the surface, unless the edges be ax or some similar substance. It seems to make the marble somewhat

considerable consumption of a variety of archil manufactured in Glasgow. steemed, and sold by the name of *cudbear*. It affords very beautiful colours on silks, of various shades, from pink and crimson to a bright mazarine blue, which are said to be very permanent.—U. (See *Ure's Dictionary of Arts, Manufactures, and Mines*, i. 175.)

ARCTIZITE. See Wernerite.

ARCTOSTAPHYLOS UVA URSI. The *bear-berry.* — An ericaceous plant which grows wild in the mountainous parts of England and Scotland, and in the north of Europe. It possesses strongly astringent properties. The leaves boiled with water yield a liquid which contains tannic acid and a large quantity of gallic acid, and may therefore be used for making ink. The same decoction contains, according to Kawalier, (Ann. Ch. Pharm. lxxx. 356) arbutin, sugar, ericolin, a resinous substance, wax, fat, chlorophyll, vegetable fibre, and a body resembling emulsin, which has the power of inducing the transformation of arbutin. The resin may be separated from the mother-liquor of the preparation of arbutin, by heating it with hydrochloric acid. It is brittle, nearly black, dark brown after trituration, and is said to consist of $C^{20}H^{17}O^{\frac{15}{2}}$, perhaps rather $C^{20}H^{17}O^{8}$. Besides these substances, H. Trommsdorff (Chem. Gaz. 1853, p. 61) also found in the leaves another crystallisable substance which could be extracted by ether, viz. *ursone.*

ARCTUVIN is deposited by evaporating the ethereal solution of the brown residue obtained by the decomposition of arbutin (p. 354), in colourless crystals, which are purified by recrystallisation from water, alcohol, and ether, with the aid of animal charcoal. It forms long prisms, which are bitter, fusible, and may be sublimed when cautiously heated. It contains, according to Kawalier's analysis, 64·4 C and 5·6 H. The formula $C^{20}H^{20}O^{7}$ requires 64·5 C and 5·4 H. Gerhardt's formula, $C^{12}H^{12}O^{4}$, requires 65·4 C and 5·4 H. If sesquichloride of iron be added, drop by drop, to an aqueous solution of arctuvin, the mixture assumes a bluish tint, gradually changing to green. With a solution of subacetate of lead containing a little ammonia, arctuvin forms a white precipitate, which soon turns brown. Arctuvin moistened with ammonia and exposed to the air gradually forms a black substance, which Kawalier calls *arctuvein;* it contains 35·9 C, 3·0 H, 12·5 N, and 48·6 O. (Gerhardt, Traité iv. 266.)

ARECA NUTS, the fruit of the areca palm (*Areca catechu, L.*), contain, as their chief constituents, catechu, a variety of tannic acid, and gallic acid, together with acetate of ammonium, fats, oil, gum, nitrogenous substances, and a dye called *areca-red,* which is of a brown colour, without taste or smell, insoluble in cold water and in ether, soluble in boiling water and alkaline liquids, whence it may be precipitated by acids. Boiled with nitric acid, it yields oxalic acid. (Morin, J. Pharm. viii. 449.)

ARENDALITE. See Epidote.

ARETHASE, a name given by Laurent to a product of the decomposition of chloride of cacodyl by alcoholic potash. (See Arsenic-radicles, Organic.)

ARFWEDSONITE. A ferruginous variety of hornblende. Colour black. Cleavage-faces much more brilliant than those of hornblende, which scratches it. Specific gravity 3·44. Melts even in the flame of a candle; boils up strongly before the blowpipe, and yields a black magnetic globule. Not soluble in acids or in caustic potash. Its composition may be represented by the general formula $Si^{6}M^{10}O^{17} = 5M^{2}O.6SiO^{2}$. A specimen from Greenland, analysed by Kobell (J. pr. Chem. xiii. 3) yielded results agreeing nearly with the formula $(15FeO.4Na^{2}O.CaO).24SiO^{2}$.

	SiO^2	FeO	Na^2O	CaO	MgO	MnO	Al^2O^3	Cl	
Analysis . .	49·27	36·12	8·00	1·50	0·42	0·62	2·00	0·24	= 98·17.
Calculation . .	52·33	36·93	8·77	1·97	. .	. .	. .	. .	= 100·00.

ARGAL or **ARGOL.** The commercial name of crude tartar in the state in which it is taken from the inside of wine-casks.

ARGENTAN. Syn. of Nickel-silver or German silver. See Nickel.

ARGENTAMMONIUM. A metallic ammonium-radicle (p. 198), containing 1 at. silver in place of hydrogen. Its oxide $(NH^{3}Ag)^{2}O$ is commonly called *fulminating silver.* (See Silver.)

ARGENTINE. A schiefer-spar mixed with silica, found at Southampton and Williamsburgh, in Massachussets. (See Calcspar.)

ARGENTINE FLOWERS OF ANTIMONY. An old name of tetroxide of antimony, or antimonate of antimony (p. 324).

ARGENTITE or **ARGYROSE.** Syn. of Silver-glance.

ARGILLACEOUS EARTH. See Alumina and Clay.

ARGYRITES. See Lead-oxide. — **ARGYROSE.** See Silver-glance.

NE. $C^{23}H^{26}N^2O^4$ (*Cinchovatine, Cusconine, Quinovine*).—An alkaloid, dis-
white cinchona bark from Arica, by Pelletier and Corriol (J. Pharm.
). Manzini (J. Pharm. [3] ii. 95) afterwards, found in a fibrous white
om Jaen, an alkaloid which he called *cinchovatine*, but which has been
Vinckler (Buchner's Répert. d. Pharm. [2] xxxi. 294; xlii. 25 and 231;
11) to be identical with aricine.

extracted from the cinchona bark in the same manner as quinine (*q. v.*),
ing the bark with acidulated water, treating the liquor with lime, and
ne lime-precipitate in alcohol. The solution, filtered at the boiling heat,
y dark-coloured liquid, which, after a while, deposits the greater part of
in crystals. An additional quantity may be obtained from the mother-
pelling the alcohol by distillation, treating the residue with a slight excess
oric acid, separating the greater part of the colouring matter by means of
solution of common salt, then precipitating the aricine by ammonia, dis-
precipitate in alcohol, decolorising with animal charcoal, and crystallising.
orms white prismatic crystals, more elongated than those of cinchonine;
dorous, and have a bitter taste, which, however, does not show itself for
on account of the sparing solubility of the alkaloid. It dissolves easily in
ecially when warm, less readily in ether. The solution blues reddened
turns syrup of violets green. The crystals, which are anhydrous, melt at
ming a brownish liquid, which blackens at a higher temperature, yielding
eumatic products. Aricine dissolves with decomposition in strong nitric
g a deep green solution: this is a very characteristic reaction.

of aricine are, for the most part, easily soluble and crystallisable. They
d by dissolving aricine in dilute acids; the solutions are precipitated
The *acid sulphate*, $C^{23}H^{26}N^2O^4.SO^4H^2$, crystallises in flattened needles
which are anhydrous (Manzini). The *neutral sulphate* does not crys-
solution in water, but forms a gelatinous mass, which dries up to a
tance (Pelletier, Ann. Ch. Phys. [2] li. 185). The *platinum-salt*,
$O^4.HCl).PtCl^4$. is soluble in alcohol, and is deposited from the solution by
evaporation in crystalline plates.

OLOCHIA CLEMATITIS. *Birthwort.*—The root of this plant,
sharp bitter taste, and was formerly much used in medicine, has been ex-
several chemists: but the results hitherto obtained are not very definite.
led with water, it yields about 0·004 of an essential oil of specific gravity
aid by Walz to be composed of $C^{11}H^8O^3$. A volatile acid, *aristolochic acid* also
the barium-salt of which contains, according to Walz, $C^8H^6Ba^2O^9$. From
extract of the root, Walz obtained an impure bitter compound, *clemati-*
^{6}, which is perhaps identical with the aristolochine obtained by Chevalier
lochia serpentaria. Frickinger obtained from the root a bitter uncrys-
ody, and also a yellow crystalline substance, *aristolochia-yellow*, perhaps
th aristolochine or clematidine. The root also contains a resin soluble in
ether. The inorganic constituents of the root are: potash 10·3, soda 4·2,
sodium 8·6, lime 9·1, magnesia 3·0, phosphoric acid (P^2O^5) 14·2, sulphuric
1·4, sesquioxide of iron 3·1, silica 4·5, sand, charcoal, and carbonic acid
nckler, Jahrb. pr. Pharm. xix. 71; Frickinger, Buchn. Répert. [3] vii.
ahrb. pr. Pharm. xxiv. 65; xxvi. 65.)

OLOCHIA SERPENTARIA. The root of this plant, which had
t repute in medicine, is now nearly fallen into disuse. Chevalier states
ive principle of it is a yellow bitter substance, which he calls *aristolochine.*
o contains an essential oil, resins, gum, &c.

SITE. See Brookite.

See Arsa.

E. A felspathic sandstone, often having a porphyritic structure, found
in the Vosges. According to Delesse (Arch. d. Sc. Phys. et Nat. de
177) it has been metamorphosed in the humid way, by taking up the
of felspar and hyalite, and gradually transformed into the Vosges sand-
and granite below.

IAN STONE. *Lapis Armenius, Armenite.*—An old name for a mixture
ure copper and limestone, sometimes mixed with copper or iron pyrites;
z coloured blue by azure copper.

A, OIL OF. Both the roots and the flowers of *Arnica montana* contain
. The oil is obtained from the flowers has a yellow to brownish green
lves in 100 pts. of alcohol, of specific gravity 0·85, becoming turbid and
nd in 10 to 60 pts. of absolute alcohol, and forms a solid resin when

treated with nitric acid. The oil from the roots has a specific gravity of 0·98 to 0·9 and a wine-yellow to brownish yellow colour; dissolves in 2 pts. of alcohol of specif gravity 0·85, and in all proportions of absolute alcohol, and becomes viscid whe treated with nitric acid. Both oils have a slight acid reaction. (Zeller, "Studie über ätherische Oele," Landau, 1850.)

ARNICINE. A bitter principle in the flowers of the *Arnica montana.*

ARPIDELITE. See SPHENE.

ARQUERITE. A silver amalgam from the mines of Arqueros in Coquimbo. Chil

ARRACK. A spirit obtained by fermenting infusion of rice. In Ceylon it is o tained from cocoa-nut toddy (palm wine).

ARRAGONITE. *Rhombic Carbonate of Lime.*—This mineral, which derives it name from the locality where it was first found, viz. in Arragon, occurs sometimes i regular crystals, sometimes in fibrous or radiated crystalline masses, sometimes as deposit or sinter from hot calcareous springs.

The crystals belong to the trimetric, rhombic, or right prismatic system, and ar derived from a right rhombic prism with angles of 116° 16′ and 63° 44′, exhibiting two directions of distinct cleavage parallel to the faces of this prism. Twin-crystal also frequently occur, likewise globular, reniform, and botryoïdal masses, sometime columnar, composed of straight or divergent fibres.

The crystals of arragonite are seldom colourless, mostly exhibiting a variety o colours; yellowish, greenish, reddish, brown, grey, &c. They have a vitreous lustre and the powder exhibits phosphorescence on a plate of hot iron. Specific gravity i the pulverulent state, and when free from air, from 2·92 to 3·8; larger masses have occasionally a specific gravity as low as 2·77. Hardness about from 3·5 to 4.

Crystals of arragonite are found in various localities; in clay and gypsum i Arragon; in clefts and cavities of the newer volcanic rocks, especially of basalt, as a Bilin in Bohemia, in Hungary, Scotland, the Feroe Isles, &c.; also in the dolerite o the Kaiserstuhl in the Breisgau; in gneiss and syonite near Dresden and in North America; in the lava of Etna and Vesuvius, &c. *Radiated arragonite*, which form crude masses having a radiated structure, is found chiefly on the Kaiserstuhl in the Breisgau, at Gergovie in Auvergne, and in Scotland. *Fibrous arragonite, iron-bloom* or *flos ferri*, occurs in globular, kidney-shaped or stalactilic mass, having a fibrous o laminar texture, and a mother-of-pearl lustre. It is found in veins of iron ore i Carinthia and Styria, Hungary and Transylvania. *Sprudelstein*, a fibrous variety o carbonate of calcium deposited from hot calcareous springs, contains both arragonite and calcspar. *Mountain milk, Rock milk* (*Bergmilch, Chaux carbonatée pulvérulente*), is, according to H. Rose, arragonite mixed with chalk; it occurs in thick, spongy, globular, or kidney-shaped masses, or as a deposit in limestone cavities in Wurtemberg, Switzerland, Bohemia, and other localities. Specific gravity 2·72 to 2·82. It contains traces of organic matter, and leaves a small quantity of charcoal when ignited in a close vessel. *Friable aphrite* (*Schaumkalk, Schaumerde*) was formerly supposed to be a variety of calcspar, but has been shown by Gustav Rose to be arragonite, pseudo-morphosed in the form of gypsum. It occurs sometimes in the form of gypsum-crystals, sometimes as a crystalline or laminar, white or yellowish-white mass. The crystals exhibit a strong nacreous lustre on the cleavage-faces. Its specific gravity, after thorough boiling with water to free it from air, is 2·98. *Alm or alme* is a mineral resembling mountain-milk, extensive formations of which are found in Southern Bavaria, where indeed it forms a subsoil many feet in thickness. *Osteocolla* (*Beinbruchstein*) is a carbonate of calcium mixed with sand and organic remains, which collects round decaying roots, and takes their peculiar forms; it is found in the neighbourhood of Berlin. Its specific gravity is 2·82. It exhibits, under the microscope, the form of arragonite mixed with granular masses.

Arragonite consists of carbonate of calcium, CO^3Ca'', or $CaO.CO^2$, sometimes pure, sometimes mixed with small quantities of the isomorphous compound, carbonate of strontium, which, in the arragonite of Molina, amounts to 4 per cent.; small quantities of the carbonates of magnesium, manganese, iron, &c., are also occasionally found in it. A peculiar variety called *tarnowitzite*, from Tarnowitz in Upper Silesia, contains 3·86 per cent. of carbonate of lead. The chemical properties of arragonite are essentially the same as those of carbonate of calcium in its other forms; dilute acids, however, act upon it less quickly than on calcspar, so that when a mixture of calcspar and arragonite is immersed in a very dilute acid, a residue of arragonite is obtained after a while.

Carbonate of calcium, in its two forms of calcspar (rhombohedral), and arragonite (rhombic or right prismatic), exhibits one of the most striking examples of dimorphism, that is to say, of the same chemical compound crystallising in two forms be-

ns (see Dimorphism). Formerly, when the existence of
the deviation of arragonite from the more ordinary form of
tributed to the presence of carbonate of strontium, which
hombic system. It was found, however that this mineral
often in extremely minute quantities, or indeed absent
emaining the same; and thus the fact of the dimorphism
ame apparent.

exhibit many differences in their physical properties.
double refraction; calcspar only one. Arragonite has less
calcspar, greater hardness and greater density. Large
ently decrepitate when heated, then swell up suddenly and
ces, or fibrous arragonite, become turbid and rotten. The
found to have the density of calcspar; indeed the change
ssage of the arragonite to the form of calspar. This action
phoses of calcspar in the form of arragonite. Mitscherlich
onite from Vesuvius, which had been converted into calc-
action of the red-hot lava, while its interior still retained

have determined the crystallisation of carbonate of cal-
other are not precisely known; it appears, however, to
orm of arragonite, when it crystallises from hot solutions.
gg. Ann. xlii. 363), the precipitate formed on mixing the
of calcium and carbonate of ammonium, consists of micro-
e, which, however, change into rhombohedrons of calcspar
the cold liquid.

nite in the deposits of hot calcareous springs points to the
entration of the liquid appears also to exert some influence.
(Compt. rend. xxxiv. 29 and 573), when gypsum is im-
tures in a concentrated solution of acid carbonate of so-
is deposited in the form of arragonite, but if the solution
lium is dilute, the deposit takes the form of calcspar. On
hat the tendency to the assumption of the arragonite form
of the crystallisation.

e starch of the *Maranta arundinacea*, a plant belonging
and cultivated both in the East and West Indies. Ac-
has the following composition: — Starch 26·00 per cent.;
1·53; chloride of calcium 0·25; water 65·60 per cent.
nt, the skinned tubers are washed and ground in a mill,
cylinders of tinned copper with perforated bottoms. To
impurity, great care must be used in every step of the
german silver are used for skinning the deposited fecula,
ne material for packing it. The drying is effected in pans,
exclude dust and insects.

pplied generically to indicate a starch or fecula; thus Port-
ed from *Arum maculatum;* East India arrow-root, from
azilian, from *Iatropha manihot;* Tahiti arrow-root, from
om the potato.

of the starches, contains $C^{12}H^{20}O^{10}$. The cheaper feculas
for genuine arrow-root; but they are readily detected by
ot is one of the most palateable and digestible of the
ice of the plant has been used as an antidote to poisons and
enomous insects. (See *Ure's Dictionary of Arts, Manufac-*

iquor, procured by the Tartars from fermented mare's milk
ate it is called *araca;* after rectification, *arsa.*

Scherbenkobalt, Fliegengift, Näpchenkobalt, Arsenicum, Re-
ὸν of Dioscorides.) *Symbol*, As. *Atomic weight*, 75.
ydrogen = 1); *Atomic volume*, $\frac{1}{2}$.

has been known from very early times, chiefly as sulphide
irst accurate investigation of its chemical nature was made
le, in 1755, discovered arsenic acid and arsenetted hydro-
scovered the solid arsenide of hydrogen. The stoïchio-
ic and its numerous sulphur-compounds, were specially
Bunsen in 1842 discovered cacodyl, an organic radicle
thyl, and several other organic arsenic-radicles have since
and others.

Occurrence.—Arsenic is found native, but much more frequently associated wit other metals and with sulphur. The ores from which it is prepared on the large scal as a principal product, in the form of metallic arsenic or arsenious oxide, are: *nati arsenic*, As; *arsenical iron*, two species, $FeAs^2$, and Fe^4As^6; and arsenical pyrite $FeAs^2 + FeS^2$. Metallic arsenic and arsenious oxide are likewise obtained as secondar products from *smaltine*, *cloanthite*, *arsenical cobalt*, *cobalt-glance*, *nickel-glance*, *copper-nickel*, *arsenical nickel*, *arsenical fahl-ores*, and other ores of similar character.

These arsenical ores are found more or less abundantly in various parts of th world, but chiefly in the mining districts of Germany and in the Spanish province o Catalonia. In small quantities, arsenic is very widely diffused, being found in th ferruginous deposits of mineral waters (Will, Ann. Ch. Pharm. lxi. 192); in nearly a iron ores (Walchner, *ibid.* 209); in the various kinds of pyrites, and in native sulphu Hence also it is almost always found in sulphuric acid, and in numerous chemical an pharmaceutical products, in the preparation of which sulphuric acid is used. In short arsenic in small quantities is one of the most widely diffused substances in natur It was said by Orfila (J. Chim. méd. xv. 462, 632) to exist also in the bones an muscles of men and animals in a state of health; but the experiments of other chemist have shown this statement to be erroneous.

Preparation.—Metallic arsenic is obtained on the large scale by heating *nati* arsenide of iron, $FeAs^2$ or Fe^4As^6, or arsenical pyrites, $Fe^2As^2S^2$, in earthen tubes retorts: the whole of the arsenic then sublimes, and iron or protosulphide of *ir* (FeS) remains behind. The retorts are laid horizontally in a long furnace, a tub made by rolling up a piece of thin iron plate, is inserted into their mouths, and a earthen receiver luted on. The arsenic condenses chiefly in the iron tube, in the for of a coherent internally crystalline mass, and when the tube has cooled, is detached b unrolling it. The arsenic thus obtained is purified, if necessary, by a second sublimation. The metal is also prepared by heating arsenious oxide with charcoal in earthe crucibles, surmounted by inverted crucibles, or by conical iron caps. This is th process adopted at Altenberg, in Silesia. It is more productive and economical tha the former, but the metal which it yields is grey and pulverulent, whereas the forme is compact and nearly white. Arsenic may also be obtained from its sulphides, b heating those compounds with a mixture of charcoal and an alkaline carbonate o cyanide of potassium. (Kerle's Hüttenkunde, iii. 4.)

Properties.—Arsenic is a very brittle metal, of a steel-grey colour. Its specif gravity in the solid state is, according to different observers, between 5·62 and 5·9 Vapour-density = 10·3995 (air = 1), or 150 (hydrogen = 1), which is double th atomic weight; hence the atomic volume of arsenic vapour is anomalous, being onl half that of hydrogen. (See ATOMIC VOLUME.) Arsenic crystallises in rhombohedron isomorphous with tellurium and antimony. It volatilises at a dull red heat, witho previous fusion, emitting a characteristic disagreeable odour resembling that of garli Its physical properties vary considerably with the manner in which it is sublime When very strongly heated, or when it condenses on a part of the subliming apparatu the temperature of which is but little below that at which arsenic volatilises, s that the metal is deposited in an atmosphere of its own vapour, it condenses in compact, nearly white mass, having a strong metallic lustre. This compact arseni scarcely oxidises in the air, even when pulverised and exposed to a temperatur of 80° C. Such is the condition of the metal obtained by heating arsenical pyrite When, on the contrary, the arsenic, as it passes into the gaseous form, become mixed with other gases (as when it is reduced from arsenious acid by charcoal), o when it is deposited on the colder parts of the subliming apparatus, it solidifies in dark grey crystalline powder, less dense than the preceding, and oxidising readily i the air, especially when heated.

Native arsenic forms botryoïdal, kidney-shaped, spherical, and conchoïdal mass varying in texture from fine-grained to compact; less frequently, indistinct rhombohedral crystals. In the recent state, it has a light lead-grey colour, but soon becom greyish-black by exposure to the air. In its chemical properties, it resembles artificially prepared arsenic. It is found in various localities of the Saxon and Bohemia mining districts, at Andreasberg in the Harz, at Kapnik in Transylvania, Kongsber in Norway, and several places in the United States of America.

Arsenic forms two principal series of compounds, analogous to those of antimony an phosphorus, viz. the arsenious compounds in which it is triatomic, *e.g.* $\overset{'''}{As}H$ $\overset{'''}{As}Cl^3$, $(\overset{'''}{As})^2O^3$, $(\overset{'''}{As})^2S^3$, &c., and the arsenic compounds in which it is pentatomic *e.g.* $(\overset{\mathrm{v}}{As})^2O^5$, $(\overset{\mathrm{v}}{As})^2S^5$, &c. Besides these, there are a few compounds into which i enters in other proportions, *e.g.* the sulphide As^2S^2, and several alloys.

inds of arsenic are isomorphous with the corresponding compounds of antimony, *e. g. rhombic* arsenious oxide is isomorphous with native tri- ny: the salts of arsenic acid are isomorphous with the corresponding

Detection and Estimation of Arsenic.

s in the dry way.—Metallic arsenic, heated with but slight access narrow test-tube, is converted into a vapour having the peculiar al- already mentioned, and condenses on the cold part of the tube in a sh-black, metallic, ring. With greater access of air, as when a small metal is heated in a wide test-tube, or in a tube open at both ends and p in a slanting position, the arsenic is converted into arsenious oxide, s on the cold part of the tube in a white crystalline ring, soluble in

f arsenic heated with charcoal or other deoxidising substances, are metallic state, the metallic arsenic thus liberated exhibiting the cha- tioned. If a small quantity of arsenious oxide be placed on charcoal, the blowpipe flame directed upon it, a greyish-white smoke is imme- accompanied by a powerful alliaceous odour; and if the arsenious with perfectly dry and coarsely pounded charcoal, and heated to red- om of a small test-tube, a ring of metallic arsenic will be deposited on the tube.

of arsenic, and the salts of arsenious and arsenic acid, are not easily ion with charcoal alone, but when heated with carbonate of potassium h a mixture of an alkaline carbonate and charcoal, or cyanide of potas- metallic arsenic with its characteristic properties.

s in the wet way. a. Of *Arsenious Compounds.*—*Hydrosulphuric* into an aqueous solution of arsenious acid, colours it yellow, and on ochloric acid, throws down the whole of the arsenic in the form of sulphide. The precipitate is said to be perceptible in a solution con- than 1 pt. of arsenious acid in 160,000 pts. of water. The precipitate n ammonia, carbonate of ammonium, and sulphide of ammonium, and without alteration by hydrochloric acid. It is likewise soluble in uantity of boiling water, and in boiling dilute hydrochloric acid, with rosulphuric acid gas. (Odling, Guy's Hospital Reports [3] i. 239.)

r added to aqueous arsenious acid produces a scarcely appreciable yellow cautiously adding ammonia, a canary-yellow precipitate of arsenite of olves with great facility in nitric acid, acetic acid, and excess of ammonia. antity of arsenic present is but small, it is difficult to avoid adding too and thus preventing altogether the formation of the precipitate. This ay however be obviated by using a solution of *nitrate of argentam-* nly called *ammonio-nitrate of silver*, prepared by treating a solution er with a quantity of ammonia sufficient to redissolve only a portion d oxide of silver, and filtering. Such a solution contains exactly the monia required to precipitate the arsenious acid as arsenite of silver. excess of nitric acid is present, a further quantity of ammonia will be alise it. In a neutral solution of an arsenite of alkali-metal, nitrate s an immediate precipitate of arsenite of silver.

of copper, on addition of ammonia, arsenious acid forms a bright green senite of copper (Scheele's green), easily soluble in acids and in am- case also, it is convenient to use a solution of *sulphate of cupram-* *onio-sulphate of copper*, $SO^4(N^2H^6Cu)''$, prepared in the same manner itrate of silver.

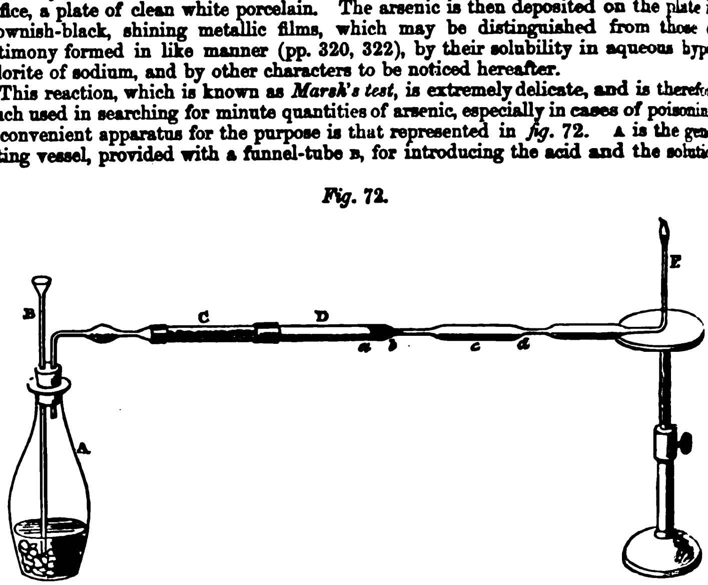
ypochlorous acid, *chromic* acid, and other *oxidising agents*, convert o arsenic acid. With a solution of *trichloride of gold*, it yields arsenic precipitate of metallic gold.

allic *copper* immersed in a hot solution of arsenious acid or an arsenite, rochloric acid, becomes covered with a grey film of metallic arsenic, ublimed and converted into arsenious oxide by heating the coated ass tube (Reinsch's test).

in a solution of arsenious acid or an arsenite acidulated with hydro- ric acid, likewise reduces the arsenic to the metallic state, part of the being deposited as a black film on the zinc, while the rest unites with rogen and escapes as gas; and from this gas, which burns with a flame, the arsenic may be separated in the metallic state, either by after drying with chloride of calcium, through a narrow glass tube, h is heated to redness over a lamp, the metal being then deposited in the cold part of the tube beyond the flame; or else by burning the gas at th extremity of the tube drawn out to a fine jet, and holding in the flame, near th orifice, a plate of clean white porcelain. The arsenic is then deposited on the plate i brownish-black, shining metallic films, which may be distinguished from those antimony formed in like manner (pp. 320, 322), by their solubility in aqueous hyp chlorite of sodium, and by other characters to be noticed hereafter.

This reaction, which is known as *Marsh's test*, is extremely delicate, and is therefo much used in searching for minute quantities of arsenic, especially in cases of poisonin A convenient apparatus for the purpose is that represented in *fig.* 72. A is the gen rating vessel, provided with a funnel-tube B, for introducing the acid and the solutio

Fig. 72.



to be tested. C is a drying-tube containing chloride of calcium; D E the reduction-tu which should be of hard glass, free from lead. It is convenient to have this tu contracted at one or two points, as shown in the figure, and turned up at right ang at the end, so as to form a vertical jet. The first thing to be done is to ascerta whether the zinc and acid are free from arsenic. For this purpose, they must be int duced into the generating vessel, without the solution under examination, and after evolution of gas has continued long enough to expel atmospheric air, the reducti tube is to be heated at *a* by a lamp-flame for about a quarter of an hour, and the set on fire at the jet F, a piece of white porcelain being held in the flame. If no position of arsenic takes place either in the tube or on the porcelain, the liquid to tested is then to be poured in through the funnel-tube and the heating continued. arsenic is present, it will be deposited in a shining mirror at *b*, a little beyond flame. After a sufficient deposit has been obtained at that point, the lamp may removed to *c*, when a second deposition will take place at *d*, and so on. If the qu tity of arsenic is considerable, spots may also be obtained on a plate of porcelain h in the flame at E. The portions of the reduction-tube containing the deposits m then be cut off with a file, sealed, and reserved for further examination. Instead burning the escaping gas at E, it may be passed, by means of a tube joined to reduction-tube by a caoutchouc connector, into a solution of nitrate of silver. Meta silver will then be deposited, and the whole of the arsenic will remain in solution arsenious acid.

A solution of arsenious acid acidulated with hydrochloric or sulphuric acid, is composed by the *electric current*, the greater part of the arsenic eliminated at negative pole being given off in the form of arsenetted hydrogen, which may examined as above (Bloxam, Chem. Soc. Qu. J. xiii. 14). The apparatus u consists of a two-ounce narrow-mouthed bottle, the bottom of which has been cut and replaced by a piece of vegetable parchment tightly stretched over it, and secu by a ligature of platinum wire (any ligature of organic nature, even vulcanised cao chouc, would be quickly destroyed by the ozone evolved at the positive pole). T bottle is furnished with a cork, carrying a small tube bent at right angles, and tached to the reduction-tube by a caoutchouc joint, also a funnel-tube for introduci the liquid to be tested. Through the cork there likewise passes a platinum w carrying a plate of the same metal, which forms the negative pole of the voltaic cuit. The bottle is placed within a glass of such a size as to leave a small inter between the two, this glass standing in a vessel of cold water. An ounce of dil sulphuric acid is introduced into the apparatus, so as to fill the bottle and the ou

, the positive plate being immersed in the acid contained
rent of a voltaic battery (6 Grove's cells of ordinary size)
arrangement, and the shoulder of the reduction-tube is
quarter of an hour, to ascertain whether any deposit of
sulphuric acid itself: if the result be negative, the liquid
d through the funnel-tube and the heating of the reduc-
s method is extremely delicate, even $\frac{1}{1000}$ of a grain of
gh a considerable quantity of liquid, producing a per-
on-tube after 15—30 minutes.

eliminating arsenic possesses certain advantages over that
se of zinc, and thereby obviates a frequent source of error
rsenic in that metal.—2. It introduces no substance into
with its subsequent examination for other metals.—3. If
it precipitates them on the surface of the negative plate.
t part precipitated in this manner. When the reduction
f present is evolved, together with the arsenic (p. 322),
of these metals is troublesome; but with the electrolytic
nly a very small quantity of antimony is evolved as anti-
n this quantity may be completely arrested by adding to
osulphuric acid. Both antimony and arsenic are then
t the sulphide of arsenic is reduced by the electrolytic
us acid (see below), whereas the sulphide of antimony
f that agent, and remains in the liquid.

—A solution of arsenic acid gives with *nitrate of silver*,
a red-brown precipitate of arsenate of silver easily soluble
d. It does not precipitate *sulphate of copper* until am-
cipitate then produced is of a pale bluish-white colour,
green. With *sulphate of magnesium*, *ammonia*, and
last being added to prevent the precipitation of hy-
acid forms a white crystalline precipitate of arsenate
n, $AsMg''(NH^4)O^4 + 6H^2O$, similar in appearance and
hate of magnesium and ammonium. If the solution
te does not appear immediately but is deposited in
the sides of the tube. *Molybdate of ammonium* added in
nate containing free nitric acid, yields, when the liquid
recipitate of arseno-molybdate of ammonium; exactly
bdate (see PHOSPHORIC ACID). This precipitate is in-
n ammonia, and in excess of the arsenic solution; hence
letecting small quantities of arsenic acid, and is indeed
ts for that acid, provided no phosphoric acid is pre-
iron and *uranium*, arsenic acid forms yellowish-white
, it forms a white precipitate of arsenate of lead, which
the inner blowpipe flame, gives off the odour of arsenic,
lead. *Hydrosulphuric acid gas* passed through a solution
w at first, and after a long time produces a yellow pre-
c, mixed with sulphur, the precipitation being accelerated
utral arsenate of alkali-metal, through which hydro-
yields the same precipitate on addition of hydrochloric
horous acid, and other *deoxidising agents* reduce arsenic
of arsenious acid. Hence in a solution of arsenic acid
or a soluble acid sulphite, hydrosulphuric acid produces
isulphide of arsenic.

y the action of zinc on dilute sulphuric or hydrochloric
o arsenetted hydrogen, which is evolved as gas (Scheele,
is much slower than with arsenious acid. When an
rough a solution of arsenic acid, metallic arsenic is
e (Gmelin's Handbook, iv.), and arsenetted hydrogen is
are present (Bloxam); on adding sulphurous acid, or
solution, whereby the arsenic acid is reduced to arsenious
ed hydrogen is greatly accelerated. The same effect is
certainty on adding aqueous hydrosulphuric acid to the
o chiefly due to the reduction of the arsenic acid to
n the hydrosulphuric acid is added in excess, the evolu-
n still takes place, the arsenic uniting with the hydrogen
(Bloxam, Chem. Soc. Qu. J. xiii. 138.)

ter, may be examined for arsenic by dissolving them in hydrochloric acid; passing hydrosulphuric acid gas through the solution; digesti the precipitate with sulphide of ammonium, to dissolve out the sulphide of arseni and precipitating the sulphide of arsenic by hydrochloric acid. The precipitate m then be dried, and reduced by heating with carbonate of sodium and charcoal, or di solved in hydrochloric acid, with addition of chlorate of potassium, and the soluti which will contain arsenic acid, tested as above.

The following characters *taken together* are sufficient to distinguish arsenic from other substances.

1. Formation of a black shining metallic sublimate by one of the methods of redu tion above described.

2. Conversion of this metallic deposit into white crystalline arsenious oxide by su limation in contact with the air.

3. Solution of this sublimate in boiling water, and production of the reactions chara teristic of arsenious acid, viz. yellow with hydrosulphuric acid, yellow with ammoni nitrate of silver, light green with ammonio-sulphate of copper.

4. Solution of the metallic sublimate in hot nitric acid, and production of the r actions characteristic of arsenic acid, viz. red-brown with nitrate of silver, whi crystalline with ammonia and magnesium-salts, bright yellow with molybdate ammonium.

The metal with which arsenic is most likely to be confounded, is antimon especially when the reduction to the metallic state is effected by Marsh's metho (pp. 320, 322.) The arsenical and antimonial deposits obtained in this manner, m however be distinguished by the following characters:

The arsenic-mirror has a strong lustre, and a black-brown, or brown-black colou thin films of it formed in a glass tube, appear perfectly translucent, with brown colou when held before white paper. On account of the volatility of arsenic, the depo is formed only at a certain distance from the heated portion of the tube, and alwa on the side *towards* which the stream of gas is directed. The spots formed on por lain have a black-brown, or when very thin, a brown or light brown colour. T antimony mirror on the contrary is formed in the reduction tube on both sides of t flame and close to it. Where most strongly heated, it has a whiter colour, and wh examined by a lens, exhibits small fused metallic globules. It is brownish in thi films, but not continuously brown and shining, like that of arsenic. Antimony-spo formed on porcelain are velvet black, and without lustre, unless very thin; in that ca they have an iron-black, or dark plumbago colour, brownish-grey at the edges.

If the part of the reduction-tube containing the arsenic-mirror be cut off, and heate in a *small* lamp flame, the flame exhibits the characteristic greyish colour, and th strong garlic odour of arsenic becomes perceptible. If the pieces of tube cove with arsenic are heated in a narrow test-tube, the characteristic white crystallin sublimate of arsenious oxide is formed, perfectly soluble in boiling water, and ex hibiting the characters above-mentioned.

The antimony-deposit does not give off any odour when heated in a lamp-flame, an if heated in a wide test-tube, yields a white shining sublimate of oxide, which is in soluble in water and in ammonia, but dissolves readily in hydrochloric acid, the solu tion yielding with hydrochloric acid the characteristic red precipitate of antimoniou sulphide.

The arsenic-mirror dissolves readily in an alkaline solution *hypochlorite of sodiu* the solution exhibiting the characters of arsenic acid. The antimony-mirror is in soluble in the same liquid, provided it does not contain free chlorine.

Nitric acid of specific gravity 1·2 to 1·3 dissolves the arsenic deposit in the cold, o at a gentle heat, the solution exhibiting the characters of arsenious acid; at a stronge heat, arsenic acid is formed. The same acid likewise dissolves the antimony mirro but the solution is turbid, gives no precipitate with nitrate of silver and ammonia orange-yellow, with hydrosulphuric acid.

A very good way to identify arsenic spots is to collect one or more in a watch-glass add a drop or two of nitro-hydrochloric acid—evaporate quite to dryness, moiste with water, and then add nitrate of silver solution.

Yellow *sulphide of ammonium* dissolves arsenic spots with great difficulty, an never completely; and on evaporating to dryness, there is always left a grey stain o arsenic in the midst of the yellow orpiment. Antimony spots dissolve at once an completely, and the orange-red sulphide of antimony left on evaporation, dissolve completely in hydrochloric acid, being converted into chloride, which volatilises, o leaves only a slight residue of white antimonious oxide.

The arsenic-deposit is easily dissolved in the cold by *hydrochloric acid with additio of chlorate of potassium*, and the solution yields, with magnesium-salts, mixed wit ammonia and tartaric acid, the crystalline precipitate characteristic of arsenic acid deposit similarly treated, dissolves only when heated, and the solution rtaric acid and ammonia is not precipitated by magnesium-salts.

etted hydrogen is passed into a solution of *nitrate of silver*, metallic itated, and all the arsenic remains in solution as arsenious acid, which tated by sulphuretted hydrogen, &c.; but when antimonetted hydrogen nitrate of silver, the whole of the antimony is precipitated in the together with the silver, and the solution, after being freed from excess drochloric acid, gives no precipitate with sulphuretted hydrogen.

pens that antimony and arsenic are evolved together as gaseous hyunds. In that case, the two metals may be separated by the reaction silver just mentioned[*]; by dissolving the metallic mirror in hydroith addition of chlorate of potassium, then adding tartaric acid and precipitating the arsenic by sulphate of magnesium; or by gently heat- in a very slow stream of dry sulphuretted hydrogen, whereby both are sulphides, and then passing dry hydrochloric acid through the tube. f antimony is thereby converted into chloride, which passes on with the and may be received in water and further tested, while the sulphide of s unaltered. If the hydrochloric acid gas is not perfectly dry, a small antimony will be left behind as oxide.

ethods of separating arsenic and antimony, see page 368.

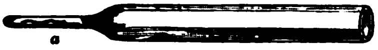
of Arsenic in cases of Poisoning.—Nearly all compounds of sonous, the most soluble being, generally speaking, those which act with olence. But arsenious oxide, commonly called *arsenious acid*, being the known and easily procured, is that which is most likely to be met with oning by arsenic, whether accidental or intentional.

oxide is but sparingly soluble in water, and is generally administered te, mixed with viscid articles of food, such as gruel or rice, it some- that, by careful examination, small lumps of it may be found adhering ssels, &c., or even to the coatings of the stomach and intestines after this is the case, the arsenic may be picked out and reduced to the by heating it with charcoal.

ious oxide is too finely divided to be picked out in this manner, it may separated by stirring up the mass several times with water, and leaving rticles to settle. Any solid arsenious acid that may be present will be d in the residue, and may then be washed with cold water and dried -bath.

hus separated may be reduced to the metallic state by heating it in be with charcoal, as described as page 361. A good way of effection, is to place the dried granules or powder at the bottom of a small n out as shown in *fig.* 73, and place above it a splinter of well-dried

Fig. 73.



The tube is first held in a horizontal position with the part *a* in the p, so as to heat the charcoal to redness; it is then gradually inclined e arsenious acid, and cause the vapour to pass over the ignited charcoal. metallic arsenic then collects at the shoulder of the tube, and may afterverted into arsenious oxide by sublimation in contact with the air, as ed (p. 361).

ntly, however, the arsenic is intimately mixed with large quantities of such as articles of food, vomited or evacuated matters, portions of the s the stomach, liver, &c. In such cases, Reinsch's test (p. 361) may be tly applied. The suspected matter, if liquid, is acidulated with about s bulk of hydrochloric acid and boiled. The solid tissue is cut up into ces and boiled for some time in a mixture of 1 pt. of hydrochloric acid, f water, till the whole is completely disintegrated, and then strained , or filtered through paper previously wetted. Pieces of copper-gauze or be immersed in the boiling liquid, and if any grey deposit is produced, ust be added as long as any perceptible alteration of colour takes place of the metal. They are then to be removed, washed with distilled

---

le of detecting small quantities of antimony thus precipitated is, after carefully washing acid, to digest the precipitate in aqueous tartaric acid; the antimony then alone dis- e tested by hydrosulphuric acid. (Hofmann, Chem. Soc. Qu. J. xiii. 79.)

water, and dried between bibulous paper, folded up, introduced into a dry test tu
and heated over a lamp. The arsenic is thereby converted into arsenious oxide, whi
collects on the cold part of the tube in the form of a crystalline sublimate. It may
dissolved in water and tested with nitrate of silver, &c. Inasmuch as Reinsch's pr
cess involves the solution of a minute quantity of copper, the foil or gauze employ
should be so far free from arsenic that the solution of four or five grains of it shou
not yield a trace of the poison.

The arsenic may also be detected by other methods which, however, for the mo
part require more complete destruction of the organic matter. This may be effect
by one of the following processes:

1. The organic matter is mixed with about a fourth of its weight of strong su
phuric acid, and heated till the whole is reduced to a dry friable carbonaceous mas
and this residue, after being pulverised, is treated with nitric acid mixed with a sma
quantity of hydrochloric acid, in order to bring the arsenic to the state of arsenic aci
which is very soluble in water. The mixture is then evaporated to dryness, and t
residue boiled with water and filtered. If the organic matter contains alkaline chlorid
which is frequently the case, care must be taken not to heat it more strongly than
necessary for complete incineration, otherwise a portion of the arsenic may be convert
into chloride and lost by volatilisation.—2. The organic matter is gently heated in
tubulated retort with strong hydrochloric acid, and nitric acid is added by sma
portions at a time. The organic matter is thereby completely destroyed, with t
exception of the fat. The liquid, which is transparent and colourless, is then decant
from the fatty matters; the latter are well washed with water; and the washings, tog
ther with the distillate in the receiver, are added to the main bulk of the liquid (Gau
tier de Claubry, J. Pharm. [3] xvii. 125).—3. Chlorate of potassium may also b
added in successive portions instead of the nitric acid.—4. The organic matter, aft
being comminuted as much as possible, may be suspended in water, and chlorine g
passed through the liquid till the organic matter is partly destroyed and partly d
posited in brown flakes.—5. The organic matter, after being dried, is mixed wit
nitre, and the mixture projected by successive portions into a red-hot crucible. T
arsenic is thereby converted into arsenate of potassium, which dissolves readily i
water. (Wöhler.)

Mr. Graham finds that a most effective separation of the organic matter capable
interfering with the precipitation of arsenic by reagents, may be effected by his app
ratus for the diffusion of liquids. A flat hoop of white wood or gutta-percha, abou
ten inches in diameter, is covered with a sound sheet of parchment-paper, so as to for
an instrument like a tambourine in form. The organic fluid is placed within t
instrument so as to cover the parchment bottom to the depth of half an inch, and t
whole is then floated upon distilled water, contained in a basin. Three-fourths of t
arsenious acid present are found to escape by diffusion and enter the water below, i
the course of twenty-four hours, giving a perfectly colourless solution. To this liqui
when concentrated, all the ordinary tests of arsenic may be applied. (See Diffusio
of Liquids.)

A clear solution having been obtained, the arsenic may be separated from it i
either of the following ways:

1. *By Precipitation as Trisulphide.*—The clear arsenical solution is saturated with su
phurous acid to reduce the arsenic acid to arsenious acid, the excess of sulphurous aci
is expelled by gentle heating, and a stream of sulphuretted hydrogen gas passed throug
the liquid for a considerable time. The precipitated trisulphide of arsenic is then car
fully washed with cold water, dried, and reduced to the metallic state by heating it in
small tube having a bulb blown at the end with a mixture of dry carbonate of sodium an
charcoal, or cyanide of potassium. The bulb, after the introduction of the mixtur
should first be gently heated over a lamp to expel moisture, the tube then wiped ou
with filtering paper, and the bulb strongly heated in the blowpipe flame. A ring
metallic arsenic is then deposited in the tube, and may be treated as already describe

2. *By Conversion into Arsenetted Hydrogen.*—This may be effected either by Marsh'
or by Bloxam's process (p. 362). The former has long been used by toxicologist
It is extremely delicate, and indeed has nearly superseded all other methods, excep
ing that of Reinsch. If the liquid to be tested has been effectually freed from
organic matter by either of the methods just given, so that there is no longer an
danger of frothing, it may be introduced, together with the zinc and sulphuric acid
into an ordinary gas-generating vessel, provided with a drying tube and reduction
tube (p. 362). Peculiar forms of apparatus have, however, been devised for perform
ing the process without the trouble of completely removing the organic matter. Suc
is the original apparatus of Marsh, a figure and description of which are given i
Graham's Elements of Chemistry, 2nd ed. vol ii. p. 215. Another form of appa
ratus, contrived for the purpose by a committee of the Prussian government, an

he late Dr. Ure, is described in *Ure's Dictionary of Arts, Manufac-*
es, new edition, i. 189.

owever, that the presence of organic matter sometimes completely pre-
ection of minute quantities of arsenic by Marsh's process (Odling,
l Reports,[3] v. 367; Pharm. J. Trans. [2] i. 374). Hence it is better in
e applying this test, to eliminate the organic matter by one of the pro-
escribed. It must be observed, however, that all these processes yield
the form of arsenic acid, so that it becomes necessary to add sulphurous
lphite of sodium, in order to reduce it to arsenious acid. Another
eding, recommended by Odling (*loc. cit.*), is to mix the suspected sub-
rong hydrochloric acid, distil to dryness and test the distillate. In this
ion of sulphurous acid is unnecessary.

ectrolytic process is of recent introduction and has not, so far as we are
et applied in judicial investigations; but it appears to present several
er that of Marsh, especially in securing, by the addition of hydrosul-
the liquid, the complete separation of arsenic and antimony, the former
olved as arsenetted hydrogen, the latter remaining wholly in the liquid.
of this separation is of especial importance in the investigation of cases
y arsenic, inasmuch as tartar-emetic is often given in such cases to pro-

sses of testing for arsenic, it is of the utmost importance to ensure that
s obtained of the presence of that substance do not proceed from the
selves. Arsenic is very widely diffused in the mineral kingdom, and
y no means an easy matter to procure reagents absolutely free from it.
l, hydrochloric acid, and zinc are often contaminated with it, and con-
sh's process, in which these reagents are employed, is very liable to give
cations, unless the precaution be taken of testing the reagents in the
dy described (p. 362) before introducing the suspected liquid. Sul-
drogen, evolved by the action of dilute sulphuric acid on sulphide of
tains arsenic, proceeding from one or both of the substances used; but
evolved by heating native sulphide of antimony with hydrochloric acid
ee from it, because sulphide of arsenic, even if present in the sulphide of
ot decomposed by hydrochloric acid. The complete destruction of organic
processes described at page 366, requires the use of considerable quantities
or hydrochloric acid; consequently the arsenic contained in the acid is
mulate in the resulting liquid in sufficient amount to make itself visible
uent examination, even though the proportion of it contained in the acid
nall to be perceptible in the comparatively small quantities required for
ting. This consideration tends rather to induce a preference for methods
require so complete a destruction of the organic matters, such as Reinsch's
ytic process.

tive Estimation of Arsenic.—When arsenic is contained in a solu-
n the form of arsenic acid, it is best to precipitate it in the form of
magnesium and ammonium, $AsMg^2(NH^4)O^4 + 6H^2O$, by mixing the
excess of ammonia, and then with sulphate of magnesium, adding also a
loride of ammonium sufficient to prevent the precipitation of hydrate of
ammonia. The liquid is left to stand for some hours, and the precipitate
n a weighed filter, and washed with water containing ammonia. It may
l, either in vacuo or sulphuric acid, in which case it retains all its water
ion—or more expeditiously at 100 °C., in which case it loses $\frac{11}{12}$ of its water,
l to $AsMg''(NH^4)O^4 + \frac{1}{2}H^2O$, or rather $2[AsMg''(NH^4)O^4] + H^2O$, from
ntity of arsenic is easily calculated.

xists in solution in the form of arsenious acid, it may either be brought
f arsenic acid by oxidation with nitric acid, and the arsenic determined
he arsenic may be precipitated as trisulphide by hydrosulphuric acid,
being previously acidulated with hydrochloric acid, and the precipitate
weighed filter, washed and dried at a temperature a little above 100° C.
hide were quite pure and definite, its quantity might be at once deter-
ucting the weight of the filter from the gross weight, and the quantity
culated from the formula As^2S^3. But, as the precipitate almost always
sulphur, the quantity of arsenic in it must be estimated by oxidising the
strong nitric acid, and proceeding in a manner exactly similar to that
en described for the estimation of antimony (p. 321).

acid may also be estimated by its reaction with trichloride of gold, which
nto arsenic acid, and at the same time yields a precipitate of metallic
at. of gold corresponding to 3 at. arsenious acid:

$$4AuCl^3 + 6H^2O + 3As^2O^3 = 4Au + 12HCl + 3As^2O^5.$$

The gold solution used for the purpose is the sodio-chloride or ammonio-chlor (see GOLD): it must be free from nitric acid.

When arsenious and arsenic acids exist together in solution, the latter may be p cipitated as ammonio-magnesian arsenate (a considerable quantity of chloride ammonium being added to prevent the simultaneous precipitation of the arsenic acid); the arsenious acid in the filtrate is converted into arsenic acid by oxida with chlorate of potassium and hydrochloric acid, and then precipitated in t same manner; or the arsenious acid may be estimated by chloride of gold, as j described.

Atomic Weight of Arsenic.—**Berzelius** (Schw. J. xxxiii. 172) determined t atomic weight of arsenic from the quantity of sulphurous anhydride produced by he ing arsenious oxide with sulphur. The equation, $2As^2O^3 + S^9 = 2As^2S^3 + 3S$ shows that 1 at. As^2O^3, yields $1\frac{1}{2}$ at. SO^2. Now in an experiment made by Berzeli 2·203 grm. As^2O^3 gave 1·1069 SO^2. Therefore:

$$As^2O^3 = \frac{2·201}{1·069} . 96 = 197·84$$

and deducting $O^3 = 48$, there results $As^2 = 149·84$ and $As = 74·92$. **Pelou** (Compt. rend. xx. 1014) decomposed pure trichloride of arsenic with water, and termined the quantity of hydrochloric acid produced by means of a standard soluti of silver. His results (calculated with the atomic weights of silver and chlorine n adopted ($Ag = 108$; $Cl = 35·5$), give as a mean of three experiments, $As = 75·$ The mean between this number and that of Berzelius is exactly 75.

Separation of Arsenic from other Elements.—From other metals of t second and third groups (ANALYSIS, INORGANIC), and from all non-metallic elemen excepting selenium, arsenic is separated by precipitation with hydro-sulphuric a gas in acid solutions. From those metals of the first group whose sulphides are i soluble in alkaline sulphides, *lead*, *copper*, *silver*, &c., it is separated by precipitati with hydrosulphuric acid, digesting the precipitate with sulphide of ammoniu and acidulating the filtered solution with hydrochloric acid. From *selenium* a *tellurium*, it is separated by sulphurous acid, which precipitates those elements fr their solutions in the free state.

Separation from Antimony.—When arsenic and antimony exist together in the for of an alloy, they may be completely separated by heating the compound to low redne in a stream of carbonic anhydride, the arsenic then volatilising and the antimony r maining. Antimony is, however, the only metal from which arsenic can be complete separated in this manner; if the alloy contains any other metal, some of the arsen will be retained, and the method is no longer applicable. When this is the case, t alloy may be dissolved in hydrochloric acid, to which nitric acid or chlorate of pota sium is gradually added; the solution diluted with water after addition of tarta acid, is then mixed with a considerable quantity of chloride of ammonium and exce of ammonia, and the arsenic precipitated by addition of sulphate of magnesium. T antimony may then be precipitated from the filtrate by hydrosulphuric acid. T mode of separation is equally applicable when the two metals are in the state sulphides; as, for instance, when they are precipitated together from solution by hyd sulphuric acid. When they occur together as oxides, they may be dissolved in hydr chloric acid, mixed with tartaric acid, and treated as above; or they may be separat by fusion with caustic soda in the manner to be presently described.

The separation of arsenic from *tin* may be effected by converting the two meta into sulphides, and separating them, after drying and weighing the whole, by igniti in a stream of hydrosulphuric acid gas. The mixed sulphides are introduced into weighed glass bulb, having a tube attached to it on each side. One of these tub the exit-tube, must be at least a quarter of an inch in diameter, to prevent stoppag and bent downwards so as to dip into a flask containing ammonia. The whole then weighed, hydrosulphuric acid gas passed through the apparatus, and the bu heated till the whole of the sulphide of arsenic is sublimed. Part of the sulphide arsenic passes into the ammoniacal liquid by which it is dissolved, and the r sublimes in the wide tube. When the operation is ended, and the apparatus h cooled, the wide tube is cut off at a short distance from the bulb, then broken, an the pieces digested in caustic potash to dissolve out the sulphide of arsenic. T solution thus obtained is added to the ammoniacal liquid in the flask; the sulphide arsenic is precipitated by hydrochloric acid, and oxidised, without previous filtratio with hydrochloric acid and chlorate of potash; and the resulting arsenic acid is pr cipitated by ammonia and sulphate of magnesium. The sulphide of tin remaining the bulb is converted into stannic oxide by treating it with strong nitric acid.

Separation of Arsenic from Antimony and Tin together.—The separation of th

is attended with considerable difficulty. The best mode of effecting it
them into arsenate, antimonate, and stannate of sodium, and treat the
dilute alcohol of a certain strength, which dissolves the arsenate and
odium, and leaves the antimonate undissolved.

e metals exist together in solution, they are precipitated as sulphides by
ic acid, and the sulphides are fused in a silver crucible with a mixture
caustic soda; or, better, they are oxidised by heating them with strong
and the solution, together with the insoluble stannic and antimonic acids,
excess of caustic soda and evaporated to a small bulk, then transferred
rucible, evaporated to dryness, and fused for some time at a red heat.
ss, consisting of arsenate, antimonate, and stannate of sodium, is disin-
igestion in warm water, the contents of the crucible are transferred to a
and the crucible is well rinsed out with a measured quantity of water.
part of the arsenate and stannate of sodium then dissolves, while the
remains undissolved. But to effect complete separation, a quantity of
cific gravity 0·833, is added equal in bulk to one-third of the water used;
s left to stand for 24 hours and frequently stirred; and the antimonate of
h has then completely settled down, is collected on a filter and washed,
mixture of 1 vol. of the same alcohol and 3 vols. water; then with 1 vol.
vols. water; next with a mixture of equal measures of water and alcohol;
ith 3 vols. alcohol to 1 vol. water.

onate of sodium, separated by this process, is digested in a mixture of
and tartaric acids, which dissolves it completely; the antimony is then
by hydrosulphuric acid, and its quantity estimated in the manner already
320).

e containing the arsenate and stannate of sodium is supersaturated with
acid, which throws down a bulky precipitate of stannic arsenate; hydro-
d gas is passed through the liquid till the white precipitate is completely
o a brown mixture of the sulphides of tin and arsenic; the whole is left to
odour of hydrosulphuric acid is no longer perceptible; the precipitate is col-
eighed filter; and the filtrate is heated for some time to expel the greater
cohol, then mixed with sulphurous acid, and again treated with hydrosul-
whereby a small quantity of sulphide of arsenic is generally precipitated.
y of sulphide of arsenic being quite free from tin, need not be added to the
des on the filter. These mixed sulphides are dried at 100° C., their total
mined, and a known quantity heated in a stream of hydrosulphuric acid
anner described at page 368. The residual sulphide of tin is then con-
stannic oxide, and the sublimed sulphide of arsenic, together with the
ty separately precipitated, is converted into arsenic acid by treatment
loric acid and chlorate of potassium, and the arsenic precipitated as am-
sian arsenate. (H. Rose, Analyt. Chem. 1851, ii. 229.)

od is long and tedious, but gives accurate results. The most troublesome
he disintegration of the fused mixture of the sodium-salts, which is very
viate this inconvenience, Professor Williamson dissolves the precipitated
the three metals in a mixture of sulphide of sodium and caustic soda,
e solution with hypochlorite of sodium. The sulphides are thereby con-
rsenic, antimonic, and stannic acids, which combine with the soda, and
rated by treatment with dilute alcohol as above.

e metals are in the state of solid oxides, the mixture may be dissolved in
acid, with addition of tartaric acid, and the metals precipitated as
before. If the metals are mixed in the form of an alloy, they may be
aqua-regia, the solution mixed with tartaric acid, then diluted, and pre-
he same manner.

d just described may, of course, be applied to the separation of antimony
rsenic alone. In these cases, however, the simpler methods above given
e.

as lately introduced a new method of separating arsenic from antimony
ending on the action of acid sulphite of potassium on the sulphides of
. When recently precipitated trisulphide of arsenic is digested with
sulphite of potassium containing excess of sulphurous acid, it dissolves
on raising the heat to the boiling point, the liquid becomes turbid from
sulphur, which, however, is dissolved for the most part by continued
phurous acid is also given off, and the liquid contains arsenite and hypo-
tassium:

$$S^3 + \underset{\text{Acid sulphite of potassium.}}{16KHSO^3} = \underset{\text{Arsenite of potassium.}}{4KAsO^2} + \underset{\text{Hyposulphite of potassium.}}{6K^2S^2O^3} + 3S + 7SO^2 + 8H^2O$$

The sulphides of tin and antimony are not affected by acid sulphite of potassium. Consequently, when a solution of these three sulphides in sulphide of potassium is precipitated by a large excess of sulphurous acid, the liquid digested for some time over the water-bath, and then boiled to expel the excess of sulphurous acid, the sulphides of tin and antimony remain undissolved, while the whole of the arsenic passes into solution, and may be precipitated from the filtrate by hydrosulphuric acid. If only sulphide of antimony is present in the residue, it may be washed with pure water; but disulphide of tin thus washed is sure to pass through the filter; hence, if tin is also present, the residue must be washed, first with a saturated solution of chloride of sodium, and then with a slightly acid solution of acetate of ammonium to remove the chloride of sodium; after which it may be dried, the ammonium salt then volatilising. The washing cannot be performed with acetate of ammonium alone, because arsenic is never completely precipitated by hydrosulphuric acid from a solution containing acetate of ammonium, that salt being in fact partly decomposed by hydrosulphuric acid into free acetic acid and sulphide of ammonium, which retains the arsenic in solution. Hence the liquid which runs through in washing out the chloride of sodium by acetate of ammonium must not be added to the first wash-water containing the arsenic. (Ann. Ch. Pharm. cvi. 8.)

Valuation of Arsenic Ores. — To ascertain the amount of metallic arsenic that can be obtained from an ore, the ore is gradually heated to redness in a retort or earthen cylinder, either alone or, if it be a sulphide, with potash or quick lime. The greater part of the sublimed arsenic may be collected on a thin iron plate rolled up and inserted into the neck of the retort, and the rest on a cone of copper foil luted on to the neck, a small aperture being left to allow the escape of gases. The sublimed arsenic is then collected and weighed. Commercial arsenious acid may be assayed in a similar manner by heating it with 16 to 20 per cent. of charcoal.

It is seldom required to ascertain the quantity of arsenious acid (anhydrous) that an ore will yield by roasting. A more frequently occurring problem is to determine the proportion of pure anhydrous arsenious acid contained in a crude product. If no other volatile substances are present, the amount of the pure anhydrous acid may be determined by sublimation in a retort; in the contrary case, the arsenious acid may be dissolved out by boiling water, and its amount ascertained by weighing the residue.

The quantity of pure sulphide which may be obtained from an ore, realgar, orpiment, arsenical pyrites, &c., is found by sublimation. (Kerl's *Hüttenkunde*, Bd. iii. 1^{te} Abth. S. 2.)

ARSENIC, ALLOYS OF. *Arsenides.*—Arsenic unites by fusion with most metals, forming alloys which are generally brittle. With *potassium* and *sodium* it forms alloys which give off arsenetted hydrogen gas when thrown into water. With *iron*, *zinc*, and *tin*, it forms brittle compounds; with *copper*, a white malleable alloy; with *gold* and *silver*, grey brittle alloys; with *lead* and with *antimony*, hard, brittle, very fusible compounds. It is introduced into the lead used in the manufacture of shot, to prevent tailing, and cause the metal to run into regular globules.

Metallic arsenides heated out of contact of air, either retain the arsenic altogether or give it up but partially. The alloys of arsenic and antimony are completely decomposed by ignition at a moderate heat in an atmosphere of carbonic anhydride, the arsenic volatilising and the antimony remaining. When an alloy of arsenic is heated in contact with the air, part of the arsenic is evolved as arsenious oxide, while the rest remains in the form of a metallic arsenite or arsenate. The arsenides of the alkali-metals dissolve in hydrochoric or dilute sulphuric acid, with evolution of arsenetted hydrogen; the arsenides of heavy metals are little, if at all, attacked by any acid, except nitric acid or aqua-regia. By fusion with nitre, metallic arsenides are converted into basic arsenates; when the arsenides of the heavy metals are fused with nitre and an alkaline carbonate or hydrate, and the fused mass is treated with water, the whole of the arsenic dissolves as arsenate of alkali-metal, and the heavy metal remains in the form of oxide free from arsenic. Arsenides are not decomposed by fusion with alkaline carbonates alone or mixed with charcoal, but if sulphur be added, a sulpharsenite or sulpharsenate of the alkali-metal is formed, and the other metal remains as sulphide free from arsenic.

Many metallic arsenides are definite compounds in atomic proportion, and in that respect differ from the generality of alloys, which are mere mixtures of their constituent metals in indefinite proportions. In this respect, as in some others, arsenic resembles the metalloïds rather than the true metals. The distinction is, however, not absolute, as many of the metals proper form with one another alloys constituted in definite atomic proportions.

Many metallic arsenides occur in natural minerals, *e.g. copper-nickel*, $\mathrm{Ni^3As^2}$, *white nickel pyrites*, $\mathrm{NiAs^2}$, *tesseral pyrites* (Co; Ni; Fe) $\mathrm{As^2}$, &c.

of Antimony, also called *Allemontite*, is found at Allemont, in the Chalanche department of Isère; also at Andreasberg, Przibram, &c.; occurring in eiss, together with native antimony, antimony ores, and arsenical cobalt. It grained, spherical, and kidney-shaped masses, with uneven fracture. Specific Hardness 3·5. It is of a tin-white colour, opaque, with a faint lustre, ral appearance more or less resembling native arsenic. It contains, accord- amelsberg's analysis, 37·9 per cent. Sb to 62·1 As, corresponding to 1 at. As [Sb = 120·3], whence it would appear that the two metals are not atomic proportions, but isomorphously mixed.
r metallic arsenides will be described with the several metals.

IC, BROMIDE OF, $\mathrm{AsBr^3}$, is prepared by shaking arsenic in powder t filled with bromine vapour—the bromide of arsenic being distilled from f arsenic; also, according to Nicklès (Compt. rend xlviii. 837), by treating rsenic with a solution of bromine in sulphide of carbon: it then crystal- the solution. It forms a white crystalline mass, which melts at 20°— pale yellow liquid, boils at 22° C., and in the fused state fumes but slightly in contact with water it is converted partly into arsenious acid and hydro- , partly into oxybromide of arsenic (p. 385).

IC, CHLORIDE OF. *Butter of Arsenic; Caustic Oil of Arsenic*, $\mathrm{AsCl^3}$. ne only known chloride of arsenic, and corresponds to arsenious oxide, $\mathrm{As^2O^3}$. ced when finely divided arsenic is brought in contact with chlorine—the ning ignited by the intensity of the combination. The same compound is distilling a mixture of 1 part of metallic arsenic and 6 pts. of corrosive also by distilling arsenious oxide with strong hydrochloric acid, or with t and sulphuric acid in excess. A colourless, oily, and very heavy liquid which is decomposed by water into arsenious and hydrochloric acid; if of water is insufficient for complete solution, oxychloride of arsenic (p. 386) . It does not solidify even at −29° C. Boils at 132°, producing a vapour ty is 6·3006 (Dumas). It evaporates in the air at ordinary temperatures, white fumes of arsenious oxide. It is highly poisonous.

-chloride of Arsenic, $\mathrm{As^2H^{21}N^7Cl^6} = \mathrm{2AsCl^3.7NH^3}$ (H. Rose, Pogg. Ann.

$\mathrm{(NH\overset{'''}{As}Cl).4NH^4Cl.NH^3}$ (Pasteur, Ann. Ch. Pharm. lxviii. 207).—Dry s passed into chloride of arsenic is rapidly absorbed, forming a white solid n is soluble in water and in alcohol, and crystallises therefrom without It is decomposed by heat, and according to Pasteur, ammonia is first given en the residue volatilises completely, yielding a sublimate, in which cubes oniac can be detected by the magnifying glass. It is decomposed by hot onia being evolved, and arsenious acid and sal-ammoniac remaining in When cold water is poured upon it, it becomes heated, gives off ammonia, a solution, yielding by spontaneous evaporation six-sided tables, which arded as a compound of chloride of arsenammonium with arsenious oxide $\mathrm{2(NH\overset{'''}{As}.Cl).As^2O^3.4H^2O}$. This compound treated with strong aqueous converted into a hard mass of long six-sided tables, consisting of *mon- rsenite*, $\mathrm{As(NH^4)O^2}$, which quickly decomposes in solution, and still more he solid state, giving off the greater part of its ammonia.

IC, FLUORIDE OF, $\mathrm{AsF^3}$, is produced by mixing 1 pt. of fluor-spar, ignition, with 1 pt. of arsenious oxide and 3 pts. of strong sulphuric acid retort, and heating the mixture till it boils. It is a transparent, colour- of specific gravity 2·73, very volatile, boiling at 63° C., and fuming strongly yen, at ordinary temperatures. The vapour is about four times as heavy as air. A drop of the liquid coming in contact with the skin evaporates antly, but nevertheless produces a painful wound, which suppurates for a ke a burn. It attacks glass but slowly in a close vessel, but in contact re, it is decomposed, yielding arsenious acid and hydrofluoric acid, which e glass. With water, it forms a clear liquid, which corrodes glass, but acks zinc or tin.

IC, HYDRIDE OF. Arsenic contains two compounds with hydrogen, d the other gaseous. The *solid arsenide of hydrogen* is obtained by passing urrent through water, the negative pole being formed of metallic arsenic; or g arsenide of potassium or sodium in water. It is a brown powder, which rogen when heated in a close vessel, and burns when heated in the air From Soubeiran's analysis, it appears to be $\mathrm{AsH^2}$.

RIDE OF ARSENIC, ARSENETTED HYDROGEN, $\mathrm{AsH^3}$, a gas analogous ion to ammonia, is obtained:—1. By dissolving arsenide of potassium in water, the solid arsenide being formed at the same time.—2. By dissolving an alloy of 1 at. arsenic and 3 at. zinc or tin, in hydrochloric or dilute sulphuric acid:

$$As^2Zn^3 + 6ClH = 2AsH^3 + 3ZnCl^2.$$

3. By dissolving zinc in hydrochloric or dilute sulphuric acid containing arsenious acid (p. 361).

$$As^2O^3 + 6Zn + \left\{\begin{matrix} 12Cl \\ \text{or } 6SO^4H^2 \end{matrix}\right. = 2AsH^3 + 3H^2O + \left\{\begin{matrix} 6Cl^2Zn \\ \text{or } 6SO^4Zn. \end{matrix}\right.$$

4. By dissolving zinc, tin, or iron in aqueous arsenic acid or in a mixture of that acid with hydrochloric or sulphuric acid:

$$2AsH^3O^4 + 8Zn = 2AsH^3 + 8ZnO.$$

This last mode of formation was first given by Scheele, and afterwards denied by Fischer (Pogg. Ann. ix. 261), who stated that aqueous arsenic acid, if quite free from arsenious acid, evolves nothing but hydrogen when treated with zinc. Gmelin, however, obtained arsenetted hydrogen with perfectly pure arsenic acid and zinc. (Handbook, iv. 264.)

5. By the electrolysis of arsenious or arsenic acid. (Bloxam, p. 361.)

The gas obtained by either of the above processes is never pure, but always mixed more or less with free hydrogen. It may be collected over water, but the most scrupulous care must be taken that not the smallest quantity be inhaled, as it is excessively poisonous, and has proved fatal in more than one instance.

Arsenetted hydrogen is a colourless gas, which liquefies at 30° C., but does not solidify even at 110° C. It has an extremely repulsive odour, and even when largely diluted with air, produces nausea, giddiness, and oppression. Small animals are instantly killed by it. It does not redden litmus. Its specific gravity, according to Dumas, is 2·695 (air = 1). One volume of the gas contains $1\frac{1}{2}$ vol. hydrogen and $\frac{1}{4}$ vol. vapour of arsenic: $[\frac{3}{2} \,.\, 0{\cdot}0693 + \frac{1}{4} \,.\, 10{\cdot}39 = 2{\cdot}701]$.

Arsenetted hydrogen is slightly soluble in water. It does not combine either with acids or with bases. It decomposes the solutions of many of the metals which are precipitated by hydrosulphuric acid, its hydrogen alone being oxidised, and the arsenic precipitated in combination with the metal. From a solution of sulphate of copper, for example, it throws down arsenide of copper, As^2Cu^3.

$$2AsH^3 + 3SO^4Cu = 3SO^4H^2 + As^2Cu^3.$$

When a mixture of this gas with free hydrogen is placed over a solution of sulphate of copper, the arsenetted hydrogen is completely absorbed and the hydrogen remains. From the salts of silver, gold, and platinum, arsenetted hydrogen precipitates the metals, and is converted into arsenious acid, which remains in solution, *e. g.*:

$$\underset{\text{Nitrate of silver.}}{6NO^3Ag} + AsH^3 + 3H^2O = 6Ag + \underset{\text{Nitric acid.}}{6NO^3H} + \underset{\text{Arsenious acid.}}{AsH^3O^3}.$$

Arsenetted hydrogen is decomposed at a red heat into free hydrogen and metallic arsenic. It burns in the air with a bluish-white flame, quite different in appearance from that of pure hydrogen, forming water and arsenious acid, which rises in white smoke, and is deposited in a white crust on a cold body, such as a piece of porcelain held just above the flame; but if the porcelain be held in the middle of the flame so as to cool it partially, then the hydrogen is alone burnt, and the arsenic, being less combustible is deposited on the porcelain in metallic spots (p. 362). This effect is precisely similar to the deposition of soot on a glass rod or other cold body held in the flame of a candle.

ARSENIC GLASS. See ARSENIC, SULPHIDES OF (p. 386).

ARSENIC, IODIDE OF. AsI^3.—Arsenic and iodine unite when gently heated together, the combination being attended with considerable evolution of heat. By distilling 3 pts. of iodine with 1 pt. of metallic arsenic, in a retort having its bulb immersed in a sand-bath, the iodide is obtained as an orange-coloured crystalline sublimate having the lustre of gold. It may also be prepared, like the bromide, by treating metallic arsenic with a solution of iodine in sulphide of carbon. It dissolves in 3·32 pts. of boiling water, and the solution, if boiled down, leaves pure iodide of arsenic; but, if left to cool slowly, deposits crystals of a compound of arsenious oxide with oxyiodide of arsenic (p. 363). The iodide may be recrystallised from boiling alcohol, and is then obtained in shining laminæ of a fine brick-red colour. Iodide of arsenic has been used in the treatment of cancer.

ARSENIC, LIVER OF. An old term for the alkaline sulpharsenites (p. 388).

ARSENIC, ORES OF. (pp. 360, 370.)

IC, OXIDES OF. Arsenic forms two well-defined oxides, viz. the *Tri-*
rsenious Oxide, As^2O^3, or AsO^3, and the *Pentoxide* or *Arsenic Oxide*, As^2O^5,
The black film which forms on the surface of the metal when exposed to the
any supposed to be a suboxide, but it is more probably a mixture of metallic
h the trioxide.

ous Oxide (or Anhydride), As^2O^3; in the hydrated state, Arsenious
is compound occurs native in the mineral *arsenite* or *arsenolite* (*q. v.*) which
lary crystals investing ores of nickel, cobalt, &c. It is formed when arsenic
in contact with free oxygen, as when the metal is heated in a glass tube
ich a current of air is passing.

arge scale, arsenious oxide is obtained as an accessory product in the roasting
l ores of tin, cobalt and nickel, and as a principal product in the roasting of
yrites. The ores are sometimes roasted on the hearth of a reverberatory
ere they are in direct contact with the flame, more generally in muffles
surrounded by the flame but prevent it from touching the material. The
od involves a larger consumption of fuel, but yields a purer product, inas-
hen the flame comes in contact with the ore, the arsenious oxide produced
lation becomes mixed with carbonaceous matter, which, in the subsequent
n, reduces a portion of the arsenic to the metallic state, and gives the product
ur.

enstein, in Silesia, arsenious oxide is prepared from arsenical pyrites. The
l to powder, is roasted in a muffle-furnace, and the vapour of arsenious
de to pass into a condensing chamber, divided into partitions, where it is
n the pulverulent state, as *crude arsenic* or *poison-flour* (*Giftmehl*). This
refined by sublimation in cast-iron pots, the tops of which are contracted
and terminate in pipes which also pass into a condensing chamber. Lastly,
arsenious oxide is again sublimed at a higher temperature, and collects in
part of the subliming vessel in the form of a glass (vitreous arsenious

, in Catalonia, arsenious oxide is obtained from arsenical pyrites by roasting
eratory furnace without muffles; in other respects, the series of operations
o that just described. At Andreasberg, in the upper Harz, argentiferous
nic is roasted to extract the silver, and arsenious oxide is obtained as a
product. It is also produced in large quantity in the roasting of tin
balt ores at Altenberg in Saxony, and of tin ores in Cornwall. (See *Ure's*
of Arts, Manufactures, and Mines, i. 185; Kerl's *Hüttenkunde*, iii. 1te Ab-
. 14.)

es.—Arsenious oxide is a white solid, which occurs in two crystalline forms
se in the amorphous state.—1. *Amorphous*, *vitreous* or *glassy* arsenious
oduced, when the vapour condenses on a surface whose temperature is but
the volatilising point of the oxide, so that before solidifying it passes
e semi-fluid state. It is transparent when first prepared, but gradually
aque, and passes into the crystalline state. Its specific gravity, according
t, is 3·7385.—2. *Octahedral arsenious oxide.* This variety is produced by
n when the vapour is cooled so quickly that it solidifies at once, without pass-
h the semi-fluid state. A hot saturated aqueous solution deposits the
gular octahedrons on cooling. Vitreous arsenious oxide is transformed into
dral variety by keeping, especially in contact with the air, and also by
water or hydrochloric acid. When 2 or 3 pts. of the vitreous oxide are
n a mixture of 12 pts. of fuming hydrochloric acid and 4 pts. of water,
olution is left to cool slowly, the arsenious oxide crystallises in
t octahedrons, the formation of each crystal being accompanied by a flash
H. Rose). The specific gravity of octahedral arsenious oxide is 2·695
t).—3. *Right Rhombic Arsenious Oxide.* This variety, which is isomorphous
e oxide of antimony, is occasionally obtained by sublimation (Wöhler),
ding to Pasteur, when a boiling solution of potash is saturated with arsenious
ft to cool. It is converted into the octahedral variety by sublimation or
in hot water.

s oxide volatilises at about 218° C., forming a colourless vapour of specific
·85. The vapour is perfectly inodorous, provided the oxide has not been
contact with charcoal or other reducing agent. The vitreous oxide may be
re it volatilises to any considerable extent; but the crystallised oxide
efore fusion. Under pressure, the oxide may be melted to a glass.

s oxide dissolves but sparingly in cold *water*, more readily in boiling water,
s oxide dissolves more readily than the crystalline variety. A hot saturated
ntains 1 pt. of the oxide or anhydrous acid in 10 or 12 pts. of water, and

on cooling deposits the greater portion, leaving a solution containing 1 pt. of the anhydrous acid in 30 pts. of water. The statements of different authors regarding the solubility of arsenious acid in water differ considerably, the discrepancy probably arising from the simultaneous occurrence of the vitreous and crystalline modificatio in the acid submitted to experiment (Gm. iv. 257). No definite hydrate of arseniou acid appears to exist. The aqueous solution is transparent and colourless, and slightly reddens litmus. (For its behaviour with hydrosulphuric acid, nitrate of silver, an other reagents, see page 361.)

Arsenious oxide dissolves in hot *dilute acids* more readily than in water, but separate out completely on cooling, without forming any definite compound. It has therefor little or no basic power. With *tartaric acid*, however, it forms a potassic double sal analogous to tartar-emetic. (See Tartaric Acid.)

It dissolves in *alkalis*, forming arsenites of alkali-metals.

It is nearly insoluble in *alcohol*, quite insoluble in *ether*.

Arsenious oxide, whether in the dry state or in solution, is one of the most violent o the acrid poisons, a dose of two or three grains being certain to cause death, unless i be very speedily ejected by vomiting, or rendered innocuous by conversion into a insoluble compound. Nevertheless it appears to be possible, by commencing with small doses and gradually increasing them, to accustom the human body to sustain without injury, doses of 4 grains or even more; and it is moreover stated, apparently on good authority, that arsenic thus taken produces a plump and healthy appearanc in those who use it, and especially increases the power of the respiratory organs, and consequently facilitates mountain-climbing under heavy burthens. The Tyrolese peasantry are said to swallow arsenic in considerable quantities for this purpose. Those who are accustomed to taking arsenic in this way, are also said to experience great depression and loss of strength if they discontinue it.

Arsenious acid in small doses is much used in medicine, chiefly in cases of skin-disease. The form in which it is most frequently administered is that of *Fowler's solution*, which is an arsenite of potassium.

The best antidote to poisoning by arsenic is ***hydrated sesquioxide of iron***, which when administered in excess, converts the arsenious acid into a basic ferric arsenite perfectly insoluble in water and in the fluids of the alimentary canal. It may be prepared by precipitating a solution of ferric chloride or sulphate with ammonia, and washing by decantation, and should then be kept under water, because when dry, its power to lay hold of arsenious acid is very much diminished. It is most efficaciou when recently precipitated, the absorbing power being somewhat diminished, even by keeping under water (Bunsen and Berthold, "Das Eisenoxyd ein Gegengift der arsenigen Säure." Göttingen, 1834). Still more effieacious, according to Fuchs, is a mixture of hydrated ferric oxide with magnesia, obtained by precipitating a solution of ferric chloride or sulphate with excess of calcined magnesia. It should be prepared at the time when it is wanted, and may be used at once, without washing, the soluble magnesium-salt produced by the reaction being rather beneficial than otherwise, inasmuch as it exerts a purgative action. When ammonia is used as the precipitant, the washing cannot be dispensed with, because arsenite of iron is somewhat soluble in ammoniacal salts. The magnesia used for precipitating the ferric hydrate must not be very strongly calcined. Magnesia itself is likewise capable of abstracting arsenious acid from solution, and forming an insoluble compound with it; but ferric hydrate is more powerful in this respect, and the mixture of the two prepared in the manner just mentioned, is more efficacious than either, probably because the ferric hydrate is spread over the surface of the particles of magnesia in a state of fine division. (Handw. d. Chim. 2te Aufl. ii. 294.)

Arsenious oxide acts both as an oxidising and as a reducing agent. It partially deoxidises many compounds rich in oxygen, *e.g. nitric acid, manganic acid, chromic acid, hypochlorous acid*, &c., being itself converted into arsenic oxide or acid. It quickly reduces *gold* from the solution of the trichloride. *Potassium, charcoal, sodium, sulphur, phosphorus*, and *zinc* deoxidise it at a red heat, separating metallic arsenic. Distilled with *acetates*, it yields cacodyl, a compound of 1 at. arsenic with 2 at. methyl, $As(CH^3)^2$, which may be recognised by its peculiar and intolerable odour. When vapour of arsenious oxide is passed over red-hot *lime*, part off it is resolved into metallic arsenic, which sublimes, and arsenic oxide which unites with the lime, forming an arsenate (Wollaston), while another portion, greater as the heat is less, unites directly with the lime, forming an arsenite (Simon). Heated with *carbonate of potassium*, it likewise yields metallic arsenic and an arsenate (Gay-Lussac). As an oxidising agent, arsenic oxide is used in the manufacture of glass, for the purpose of converting protoxide of iron into sesquioxide, which yields less highly coloured glasses than the protoxide.

Arsenites.—Arsenious acid unites with bases in several proportions, but the salts

stable, and have been but little examined. Those whose composition is
$\mathrm{{}^2O.As^2O^3}$, are generally regarded as neutral; and besides these there are
es containing $\mathrm{M^4As^2O^5}$, or $\mathrm{2M^2O.As^2O^3}$, and $\mathrm{M^3AsO^3}$, or $\mathrm{3M^2O.As^2O^3}$, besides
Arsenious oxide dissolves in caustic *potash* or *soda*, but does not neu-
lkali; the concentrated solutions are decomposed by the carbonic acid in
yield, after a while, very large and well formed crystals of anhydrous
id. The acid dissolves in *ammonia* more readily than in water, and
from ammonia when the solution is evaporated. *Lime*, *baryta*, and *stron-*
when boiled with water and excess of arsenious acid, and on adding lime-,
rontia-water in excess to the solutions, basic salts are precipitated in white
se precipitates dissolve in acids and in ammoniacal salts: hence arsenious
be precipitated by the alkaline earths from solutions containing ammo-
The other arsenites are insoluble in water, and are obtained by precipi-
y dissolve in hydrochloric acid, and some of them in acetic acid, also in
lrochlorate, and nitrate of ammonium.

of the alkaline arsenites give a light green precipitate with *cupric salts*,
rith *nitrate of silver*.—*Hydrosulphuric acid* produces no precipitate unless
cid is present in excess; but all arsenites when dissolved in hydrochloric
precipitate with hydrosulphuric acid; and if the metallic base of the
kewise precipitable by hydrosulphuric acid, a compound metallic sulphide
ased.

nites are decomposed by *heat*: some give off arsenious oxide, and leave the
form of oxide: but the arsenites of the alkali-metals and the alkaline earth-
off metallic arsenic and leave a salt of arsenic acid ($\mathrm{5As^2O^3 = 3As^2O^5}$ +
nite of silver gives off arsenious oxide and leaves a mixture of metallic
rsenate of silver; arsenite of lead alone withstands a red heat without
n, and arsenite of magnesium is but imperfectly decomposed (Simon,
ri. 435).—Arsenites heated with *charcoal* give off metallic arsenic.

of Ammonium, $\mathrm{NH^4AsO^2}$, or $\mathrm{(NH^4)^2O.As^2O^3}$, according to Pasteur;
, or $\mathrm{2(NH^4)^2O.As^2O^3}$, according to Stein, is produced, according to Pasteur,
strong aqueous ammonia is poured upon arsenious oxide, and forms a
omposed of microscopic six-sided tables belonging to the trimetric system.
ly in contact with ammonia, quickly giving off ammonia in contact with
forms a yellow precipitate with silver-salts, the solution turning acid. It
in alcohol and in ether.

of Antimony.—Produced by digesting metallic antimony with
nic acid, and is precipitated on diluting with water. It may also be ob-
transparent, fused, vitreous mass, by heating metallic arsenic with anti-

of Barium, $\mathrm{Ba''As^2O^4}$, or $\mathrm{Ba''O.As^2O^3}$, is obtained by mixing a solution
of barium with acid arsenite of potassium, separating after a few hours as
mass or in dendritic ramifications. In this state it is very soluble in
ecomes sparingly soluble after drying: the liquid decanted from the jelly
lds the salt by evaporation, as a heavy sparingly soluble powder. The
ass is probably a hydrate. A salt containing $\mathrm{2Ba''O.As^2O^3 + 4H^2O}$ is ob-
rding to Stein, by dropping baryta-water into aqueous arsenious acid as
ecipitate continues to form, and washing with dilute alcohol. It gives off
100° C., and the rest at a higher temperature, arsenic, however, volatilising
time.

rated solution of arsenious acid is immediately precipitated by baryta-
y dilute solution after some time only, or not at all (L. Gmelin). Arse-
onium precipitates solution of chloride of barium after a while.

of Calcium.—The several arsenites of potassium, added to solution
of calcium, yield precipitates, but not of constant composition (Filhol).
salt, $\mathrm{Ca''As^2O^4}$, is obtained, according to Simon, by precipitating chloride of
ammonia saturated with arsenious acid; the precipitate is increased by
ss of ammonia, but dissolves partially when washed with water. When,
hand, an aqueous solution of arsenious acid is mixed with excess of lime-
te heavy powder ($\mathrm{2Ca''O.As^2O^3}$, with water) is precipitated, which is very
in water, somewhat more soluble in the presence of ammonia-salts, or of
potassium or sodium. According to Stein, the precipitate thus ob-
mixture of several basic salts, but on adding sufficient arsenious acid to
t of it the residue consists of $\mathrm{3Ca''O.2As^2O^3 + 3H^2O}$; this salt gives off
of 100° C., the rest at a temperature at which decomposition begins.

If $O = 8$, the formulæ are $MO.AsO^3$, $2MO.AsO^3$, and $3MO.AsO^3$ respectively

According to **Kühn** (Jahresb. f. Chem. 1852, 379), a boiling solution of arsenio acid added to excess of lime-water throws down the salt, $3Ca''O.As^2O^3$, or $Ca^3As^2O^6$.

Arsenite of Cobalt, $3Co''O.2As^2O^3 + 4H^2O$, is obtained by quickly mixin arsenite of potassium with a solution of chloride of cobalt containing a large excess o sal-ammoniac.

Arsenite of Copper, $Cu^2As^2O^5$, or $2Cu''O.As^2O^3$, is obtained by precipitating salt of copper with arsenite of potassium, or with arsenious acid and a sufficient quantit of ammonia to neutralise the acid present (p. 361). It is a light green precipitat (Scheele's green), which dissolves in excess of ammonia with bright blue colou yielding a solution of arsenic acid and cupric oxide. Arsenite of potassium containin excess of alkali dissolves it readily, with blue colour, but the solution quickly decom poses into arsenate of potassium and cuprous oxide. Vapour of arsenious oxide passe over red-hot cupric oxide does not combine with it.

Aceto-Arsenite of Copper, $3Cu''As^2O^4.C^4H^6Cu''O^4$. *Schweinfurt Green*, or *Imperial Gree* —This compound, the preparation of which is given at page 15, is much used as a pigment, on account of its splendid green colour. A great deal of needless alarm ha lately been excited about the supposed deleterious effects of this pigment. It is extensively employed for staining wall-papers, and persons inhabiting rooms thus papere are said to have had their health seriously deranged by the *arsenical fumes* evolve from it! Now it is utterly impossible that arsenic should volatilise from such a compound at ordinary temperatures: it does not decompose at any temperature belo redness. The only way in which danger could arise from the use of paper staine with an arsenical colour, is that particles of the compound might be brushed off i in dusting the paper, and thus become mixed with the air of the apartment; but it i not in this way that the supposed accidents are said to have occurred; the panic ha arisen from a mistaken notion as to the volatility of the arsenic. That the use of th pigment is not really dangerous may be safely inferred from the fact that no ba effects are experienced by the workmen engaged in its manufacture. (See *Ure* *Dictionary of Arts, Manufactures, and Mines*, i. 157.)

Arsenite of copper forms a similar double salt with *butyrate* of copper.

Arsenites of Iron.—There are several basic *ferric arsenites*. When recentl precipitated ferric hydrate is digested with a concentrated solution of arsenious acid in such proportion that the quantity of anhydrous ferric oxide present is equal to te times the weight of anhydrous arsenious acid, the acid is completely removed from th liquid. With a smaller proportion of ferric oxide, the precipitation is nearly thoug not quite complete. The products formed are basic arsenites containing $3Fe^2O^3.As^2O^3$, &c., from which part of the arsenious acid may be extracted by water. It is thi power possessed by hydrated ferric oxide of removing arsenious acid from a solution, which renders it so useful as an antidote to arsenious acid (p. 374).

Arsenious acid, or arsenite of potassium, forms with ferric acetate an ochre-yello precipitate, which dries up to a brown mass containing $4Fe^2O^3.As^2O^3 + 5Aq$, and when heated gives off water and the greater part of the acid (Bunsen), the whole, according to Simon. Water removes part of the arsenious acid; strong mineral acids dissolves the salt completely. Ferric sulphate or chloride is not precipitated by free arsenious acid: but gives with arsenite of potassium, according to Guibourt, a rusty-brown precipitate, containing when dry, $2Fe^2O^3.As^2O^3 + 7H^2O$. According to Damour, this precipitate is slowly dissolved, with rusty-brown colour, by caustic potash, and when slowly heated, melts before giving off arsenious oxide. A rusty yellow precipitate, likewise containing $2Fe^2O^3.As^2O^3 + 7H^2O$, is obtained by oxidising a solution of ferrous sulphate with aqua-regia, neutralising with ammonia, and precipitating by soda-ley, which has been saturated at the boiling heat with arsenious acid and freed from the excess of that acid by cooling. It is soluble in caustic soda, and the solution, evaporated to dryness, yields a red mass perfectly soluble in water.

Ferrous Arsenite, $2Fe''O.As^2O^3$, is obtained by mixing ferrous sulphate with a solution of arsenious acid in ammonia, as a greenish white precipitate, which becomes ochre-yellow on drying. The non-oxidised compound is soluble in ammonia.

Arsenite of Lead.—The *neutral* salt, $Pb''O.As^2O^3$, or $Pb''As^2O^4$, is obtained by precipitating neutral acetate of lead with acid arsenite of potassium, or with arsenious acid (**Filhol**), or, according to Berzelius, with ammonia which has been saturated with arsenious acid while warm; the precipitate obtained by the latter process contains water, becomes strongly electrical by friction, and when heated gives off some of its acid and water, and melts to a yellowish glass. Neutral arsenite of lead is somewhat soluble in water, insoluble in potash, but soluble in soda. The *diplumbic* salt, $Pb^2As^2O^5$, or $2Pb''O.As^2O^3$, is formed, according to Filhol, by precipitating neutral acetate of lead with basic arsenite of potassium, or, according to Berzelius, by precipitating basic acetate of lead with an ammoniacal solution of arsenious acid. It is a white hydrated

oluble in water and in ammonia-salts, melting to a yellowish glass when
ccording to Simon, it is obtained by passing the vapour of arsenious oxide
t oxide of lead, as a sulphur-yellow, easily fusible glass which sustains a
degree of heat without decomposing. A *triplumbic salt*, $3Pb''O.As^2O^3$,
, is obtained by precipitating basic acetate of lead with a boiling solution
acid. (Kühn.)

e of Magnesium.—Calcined magnesia, boiled with arsenious acid, takes
n of it, but not in any definite amount. A precipitate of uncertain com-
btained by mixing sulphate of magnesium with acid arsenite of potassium,
g. A solution of sulphate of magnesium is not precipitated by aqueous
id; but on adding a small quantity of ammonia, a copious precipitate is
h, according to Stein, has, after drying over sulphuric acid, the composition
r $3Mg''O.As^2O^3$. It is insoluble in ammonia, but dissolves in a large excess
niac. (H. Rose.)

s of Manganese, $3Mn''O.2As^2O^3 + 5H^2O$, is obtained, by treating a
solution with arsenite of ammonium, as a rose-coloured precipitate, which
idly in the air, gives off 1 at. water at 100° C., and at a higher temperature
senious oxide and metallic arsenic, leaving a residue of manganese and
arsenate.

s of Mercury.—The *mercuric* salt is obtained, by precipitating mercuric
arsenious acid, as a white powder soluble in nitric acid. It dissolves also
of potassium, and if the solution contains excess of potash, a black deposit
metal is immediately formed. The *mercurous* salt is obtained by double
on, or by digesting mercury in arsenic acid, as a white precipitate soluble
d.

of Nickel.—The salt $2Ni''O.As^2O^3$ is precipitated on adding arsenite of
o a nickel-salt. A less basic salt, $3Ni''O.2As^2O^3 + 4H^2O$, is produced,
Girard (Compt. rend. xxxiv. 918), by quickly mixing a solution of
ickel containing a large excess of sal-ammoniac, with arsenite of potassium.
enish precipitate, which gives off 10·3 per cent. (4 at.) water at 110° C.
d in the air, it first gives off its water, and then yields a sublimate of
ide, leaving yellow infusible arsenate of nickel:

$$3Ni''O.2As^2O^3 + O^2 = 3Ni''O.As^2O^5 + As^2O^3.$$

nickel dissolves with violet colour in ammonia. It is converted by nitric
senate; by hydrochloric acid into arsenious acid and chloride of nickel.

of Potassium.—The *neutral* or *monopotassic salt*, $KAsO^2$, or $K^2O.As^2O^3$,
by boiling the acid salt for some time with carbonate of potassium, and
e residual salt several times with alcohol: it then remains as a syrupy
eur). Filhol was not able to prepare it pure. An *acid salt*, $K^2O.2As^2O^3$ +
ained, by boiling potash-ley with excess of arsenious acid, whereby an alka-
produced, which gives with silver-salts a yellow precipitate, $2Ag^2O.As^2O^3$,
arsenious acid, the liquid at the same time becoming acid. On mixing the
uid with alcohol, it becomes thick and turbid, deposits after a few days
gular prismatic crystals, adhering to the sides of vessel and after a longer
es completely to a saline mass. The salt gives off 1 at. water at 100° C.,
hould perhaps be regarded as $2KHAs^2O^4 + H^2O$ (Pasteur). The *basic* or
salt, $2K^2O.As^2O^3$, is obtained by mixing the neutral salt with excess of
nd precipitating by alcohol. It is very soluble in water, and yields with
yellow precipitate of the diargentic salt, $2Ag^2O.As^2O^3$, the liquid remain-

ith Iodide of Potassium.—A solution of iodide of potassium yields with
id or arsenite of potassium, a precipitate, $2KI.3As^2O^3$, which is sparingly
ld water, dissolves in 19 pts. of boiling water, and decomposes at 315° C.,
d with sulphuric acid (Emmet, Sill. Am. J. [2] xviii. 583). By passing
d gas into a solution of this salt in a small quantity of boiling water mixed
times its volume of hot alcohol, and evaporating the resulting syrupy
ystallised compound is obtained, consisting of $2KI.3(K^2O.H^2O.As^2O^3)$,
$AsO^2) + 3H^2O$. This salt is soluble in water and in alcohol, and reacts
c salts like a mixture of iodide and arsenite of potassium. Strong sul-
decomposes it, forming a red or yellowish precipitate of arsenious iodide.
urated solution of this salt deposits on cooling, nodular masses, or, when
id gas is passed through it, a white powder, consisting of the salt
$^2O.3As^2O^3$), or $2(KI.KHAs^2O^4).As^2O^3$, which is sparingly soluble in
hen heated in a narrow glass tube, gives off vapour of water and metallic

arsenic, together with arsenious oxide. No iodine is given off unless the air ha access to the salt. (E. Harms, Ann. Ch. Pharm. xci. 371.)

Arsenite of Silver.—The *tetrargentic* salt, $2Ag^2O.As^2O^3 = Ag^4As^2O^5$, is forme as a yellow precipitate on treating solutions of silver salts with alkaline arsenite (pp. 361, 375). It gradually turns dark grey when exposed to the air, blackens if expose to light. When heated, it gives off, according to Simon, first water, then arseniou oxide, and leaves a mixture of arsenate of silver with metallic silver.

Another arsenite of silver is obtained, according to Filhol, as a light yellow pre cipitate on adding ammonia saturated with arsenious acid to an ammoniacal solutio of nitrate of silver. Between 140° and 150° C. it blackens suddenly, without loss o weight, and at a higher temperature melts and gives off arsenious oxide.

It is easily soluble in acetic acid (whereby it is distinguished from phosphate o silver); soluble also in potash. The latter solution is not precipitated by chloride o potassium, but, on the contrary, is capable of dissolving an additional quantity o chloride of silver. It slowly deposits metallic silver, while arsenate of potassiu remains in solution. When a solution of chloride of palladium or platinum is mixe with arsenite of potassium, and then with arsenite of silver and potassium, th platinum or palladium separates quickly in the metallic state. (Reynoso.)

Sesqui-argentic Arsenite, $3Ag^2O.2As^2O^3$, or $Ag^2O.4(AgAsO^2)$, is produced as a whit precipitate, with evolution of ammonia, when nitrate of silver, mixed with a larg excess of nitrate of ammonium, is added by drops to arsenite of potassium. It i blackened by light, dissolves in ammonia and in excess of arsenite of potassium, an when heated blackens, yields a sublimate of arsenious oxide, and leaves a fusibl residue of a fine red colour. (E. Harms and others.)

Arsenite of Sodium.—According to Pasteur, the sodium-salts of arsenious aci correspond exactly to the potassium-salts, excepting that the acid salt does not crys tallise. Filhol did not obtain the neutral salt in a state of purity.

Arsenite of Strontium.—$Sr''As^2O^4 + 4H^2O$.—Strontia-water is not precipitate by aqueous arsenious acid in any proportion, even on boiling (Gmelin). Chloride o strontium is precipitated by arsenite of potassium, but only after some days. Th precipitate gives off one-fourth of its water at 100° C.

Arsenites of Tin.—Both the *stannic* and the *stannous* salts are white precipitates the former is difficult to fuse.

Arsenic Oxide, As^2O^5, or *AsO*^{5}. In the hydrated state, **Arsenic Acid.**—Thi compound is produced by oxidising arsenious oxide or arsenious acid with nitric acid aqua-regia, hypochlorous acid, or other oxidising agents.—1. When 4 parts of arseniou oxide are gradually added to 3 pts. of nitric acid of specific gravity 1·35, the mixtur becomes hot, and after 24 hours yields a syrupy liquid like strong oil of vitriol, consist ing of arsenic acid, still containing a little arsenious acid, which may be completel oxidised by the addition of a small quantity of nitric acid. This process is used fo the preparation of arsenic acid on the large scale (E. Kopp).—2. Four parts o arsenious oxide are heated with 1 pt. of hydrochloric acid, 12 pts. of nitric acid ar gradually added (Mitscherlich), and the resulting solution is evaporated to a syrup Both the oxidation and evaporation must be performed under a chimney having good draught, because part of the arsenic is converted into chloride, which escapes i vapour.—3. Arsenic acid is also produced, together with hydrochloric acid, by passing chlorine gas into aqueous arsenious acid.

Arsenic acid forms three hydrates analogous to those of phosphoric acid, viz.:

Monohydrate . . $H^2O.As^2O^5$, or $HAsO^3 = \left.\begin{matrix}(AsO^2)' \\ H\end{matrix}\right\}O$ *

Dihydrate . . $2H^2O.As^2O^5$, or $H^4As^2O^7 = \left.\begin{matrix}(As^2O^3)^{iv} \\ H^4\end{matrix}\right\}O^4$

Trihydrate . . $3H^2O.As^2O^5$, or $H^3AsO^4 = \left.\begin{matrix}(AsO)''' \\ H^3\end{matrix}\right\}O^3$

The syrupy solution obtained as above, deposits, after standing for some time a 15° C. (60° F.), transparent, rather long prisms or rhomboïdal laminæ, containing $3H^2O.As^2O^5 + H^2O$, or $2H^3AsO^4 + H^2O$;—they deliquesce rapidly in the air, and dissolve in water with great reduction of temperature. Both the water of crystallisa- tion and the basic water may be expelled by heat.

The crystals heated to 100° C., first melt, and then yield the *trihydrate*, H^3AsO^4, a a crystalline precipitate. The same compound may be obtained in large transparent crystals by exposing a concentrated solution of arsenic acid to a very low temperatur

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* If O = 8, the formulæ are $HO.AsO^5$, $2HO.AsO^5$, and $3HO.AsO^5$.

sily in water, without reduction of temperature. The *dihydrate*, $H^4As^2O^7$,
regarded as a compound of the mono- and tri-hydrates, is obtained by
ystallised acid, $2H^3AsO^4.H^2O$, for some time to 140°—160° C.; it then sepa-
shining crystals, leaving a mother-liquor of specific gravity 2·36 at 16° C.
water with moderate facility, but the solution is attended with great
ature.
ydrate, $HAsO^3$, is formed by heating the before-mentioned crystals to
last to 206° C.; the mass then suddenly becomes pasty, gives off a large
queous vapour, and is ultimately converted into a white nacreous sub-
ting chiefly of the monohydrate; it dissolves slowly in cold water,
e facility in warm water, producing great evolution of heat. (E. Kopp,
s. [3] xlviii. 196.)
ide, Arsenic Anhydride, Anhydrous Arsenic Acid, Pentoxide of Arsenic,
ined by heating either of the hydrates to dull redness, and remains in
white mass, which has no action upon litmus; is nearly insoluble in
ammonia; and scarcely absorbs water from moist air, even in the course
s, deliquescing only after a long time. At a full red heat, it is resolved
oxide and free oxygen.
ns of the three hydrates and of the anhydride exhibit exactly the same
hey have a sour metallic taste, and all contain the trihydrate, the other
immediately converted into that compound when dissolved in water: in
he hydrates of arsenic acid differ essentially from those of phosphoric acid.
de is reduced to the metallic state by *charcoal*, *metals*, *cyanide of potas-*
red heat, in the same manner as arsenious oxide. Aqueous arsenic acid
and *iron*, with evolution of pure hydrogen; but if sulphuric or hydro-
present, the arsenic acid is reduced, metallic arsenic, and solid arsenide
re deposited, and arsenetted hydrogen gas is evolved (p. 363). An *electric*
d through aqueous arsenic acid acidulated with sulphuric or hydro-
liminates arsenetted hydrogen, provided the solution does not contain
xam). *Sulphurous acid* reduces arsenic acid to arsenious acid, with
sulphuric acid. *Hydrosulphuric acid* slowly precipitates trisulphide
e action being assisted by heat, or by the presence of another acid.
of sodium added to a solution of arsenic acid containing hydrochloric
throws down trisulphide of arsenic mixed with sulphur:

$$5Na^2S^2O^3 + 2H^3AsO^4 = As^2S^3 + S^2 + 5Na^2SO^4 + 3H^2O.$$

id and its salts are very poisonous, but not in so high a degree as
and the arsenites (Wöhler and Frerichs, Ann. Ch. Pharm. lxv. 335).
tion of arsenic acid placed upon the skin produces blisters like burns.
d is now extensively used in calico printing, in place of tartaric acid, for
ite patterns on a coloured ground in the chloride-of-lime vat.

.—Arsenic acid is a strong acid, expelling all the more volatile acids
lts at high temperatures. It is tribasic like ordinary phosphoric acid,
rmula of its salts being M^3AsO^4, in which 1 or 2 at. M may be replaced
* The solutions of the *tri-* and *di-*metallic salts, M^3AsO^4, and M^2HAsO^4;
lled *basic* and *neutral*) have an alkaline or neutral reaction; those of the
(or *acid*) salts, MH^2AsO^4, have an acid reaction. The di- and mono-
ates give off their water when heated, but take it up again on being dis-
ter: consequently there are no arsenates corresponding to the pyro-
sphates.
tes of the alkali-metals are soluble in water; of the others, only the
salts are soluble in water; but the di- and tri-metallic salts dissolve
e arsenic acid, and in the stronger mineral acids, less easily in acetic
solutions of salts of the earth-metals and heavy metals are precipitated
f potassium, but not by free arsenic acid.
allic arsenates of barium, strontium, and calcium, are insoluble in water,
ammoniacal salts; hence solutions containing arsenic acid together with
ies of ammoniacal salts are not precipitated by the salts of barium,
d calcium. When solutions of metallic salts are precipitated by a dime-
e of an alkali-metal, an insoluble trimetallic arsenate, M^3AsO^4, is often
quid at the same time acquiring an acid reaction.
of an arsenate in hydrochloric acid is slowly precipitated by *sulphuretted*
precipitate consisting of trisulphide of arsenic and sulphur in the pro-
pentasulphide; and if the metallic base of the salt is likewise thrown
huretted hydrogen from an acid solution, a precipitate is formed consist-
llic sulpharsenate. A solution of an *alkaline sulphide*, with subsequent

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diatomic metals, the formulæ are $(M'')^3As^2O^8$, $M''HAsO^4$, and $M''H^4As^2O^8$.

addition of hydrochloric acid, acts in the same manner as sulphuretted hydrogen. An aqueous solution of an arsenate boiled with *hyposulphite of sodium*, deposits trisulphide of arsenic and sulphur on addition of hydrochloric acid. *Potash* withdraws from the insoluble arsenates the whole or part of the arsenic acid.

Solutions of the tri- and di-metallic arsenates of alkali-metal give white precipitates with *baryta-* or *lime-water*, also with salts of *barium*, *strontium*, *calcium*, the *earth-metals*, *manganese*, *zinc*, and *lead*, also with *stannous* and *ferric* salts; yellowish-white with *uranic* and *mercurous* salts, yellow with *mercuric*-salts; rose-coloured with *cobalt*-salts, green with *nickel*-salts; pale greenish blue with *cupric* salts; light brown with *platinic* salts; brown-red with *silver*-salts. These precipitates are for the most part soluble in arsenic, sulphuric, hydrochloric, and nitric acid, and in ammoniacal salts: arsenate of silver, however, is not soluble in ammoniacal salts.

Magnesium-salts mixed with sufficient chloride of ammonium to prevent precipitation by ammonia, give with solutions of arsenates, a white crystalline precipitate of arsenate of magnesium and ammonium, insoluble in aqueous ammonia and in chloride of ammonium; the latter character distinguishes it from the corresponding salt of arsenious acid (p. 377).—Solutions of arsenates added to excess of *molybdate* of ammonium containing nitric acid, form, when the liquid is heated, a bright yellow precipitate of arseno-molybdate of ammonium.—All arsenates dissolved in water or in nitric acid, give with *basic acetate of lead*, a white precipitate of arsenate of lead, which when ignited with charcoal, melts and is reduced, with abundant evolution of metallic arsenic. The last three reactions afford very delicate tests for arsenic acid. The reaction with uranic salts is also very delicate, being perceptible to the twenty-thousandth degree of dilution.

The **arsenates** are isomorphous with the corresponding **phosphates**.

Arsenate of Aluminium, $2Al^2O^3.3As^2O^5$, is obtained by double decomposition as a white precipitate, easily soluble in free acid, and remaining as a vitreous mass when the solutions are evaporated.

Arsenate of Ammonium.—The *triammonic* salt, $(NH^4)^3AsO^4$, is obtained by supersaturating a strong solution of arsenic acid with ammonia, as a heavy soluble powder, which, when slightly heated, is quickly converted into the following salt:—The *diammonic* salt, $(NH^4)^2.H.AsO^4$, is formed in the manner just mentioned, and also by saturating a strong solution of arsenic acid with ammonia till a precipitate begins to form; by leaving the solution to evaporate, it is obtained in prismatic crystals of the trimetric system, which effloresce in the air, giving off half their ammonia, but no water. When heated, it decomposes, yielding metallic arsenic, ammonia, water, and nitrogen gas. Its solution has an alkaline reaction. The *monammonic* or *acid* salt, $NH^4.H^2.AsO^4$, is obtained by imperfectly saturating arsenic acid with ammonia. It is deliquescent, very soluble in water, and separates from the solution by spontaneous evaporation in square-based octahedrons. It is decomposed by heat like the preceding. Its solution has a strong acid reaction.

Arsenate of Barium.—The *tribarytic* salt, $Ba^3As^2O^8$, is obtained as a white powder, nearly insoluble in water, by precipitating aqueous arsenic acid with baryta-water (Laugier), or better, by gradually dropping trisodic arsenate into chloride of barium (Graham). The *bario-monohydric* salt, $2Ba''HAsO^4$, is obtained when a solution of the disodic salt is added drop by drop to an excess of chloride of barium. If, on the other hand, the arsenate of sodium is in excess, the precipitate formed is a mixture of the di- and tri-barytic salts, while monobarytic arsenate remains in solution. The di-barytic salt contains, according to Mitscherlich, ½ at. water ($2Ba''HAsO^4 + H^2O$); according to Berzelius, 2 at. It gives up its water at a red heat. In contact with water, it is resolved into the monobarytic salt, which dissolves, and the tribarytic salt, which remains undissolved (Berzelius). The *bario-tetrahydric* salt, $Ba''H^4As^2O^8$, is obtained by adding baryta-water to aqueous arsenic acid till a precipitate begins to form; also by treating the dibarytic salt with water, or better, by dissolving it in aqueous arsenic acid, and leaving the solution to crystallise. If a very large excess of arsenic acid be used, the solution evaporated nearly to dryness, and the mass treated with water, there remains a white powder, consisting of an acid salt containing $Ba''O.3H^2O.2As^2O^5 + 2H^2O$, or $Ba''H^4As^2O^8.As^2O^5 + 3H^2O$. (Setterberg.)

Arsenate of Barium and Ammonium, $Ba''(NH^4)AsO^4 + \frac{1}{2}H^2O$, is obtained by mixing the dibarytic salt with ammonia (Baumann), and $Ba''(NH^4)^2H^2As^2O^8$, by mixing a solution of nitrate of barium with arsenic acid (Mitscherlich); both salts are formed as bulky precipitates, which become crystalline after a while.

Arsenate of Calcium.—The *calcio-monohydric salt* occurs native, as *Haidingerite*, $2Ca''HAsO^4 + H^2O$, and *Pharmacolite*, $2Ca''HAsO^4 + 5H^2O$, and may be prepared like the corresponding barium-salt. The *calcio-tetrahydric salt* is soluble, the *tricalcic salt*

water; the latter is obtained by precipitating chloride of calcium in
isodic arsenate. (Graham.)

Calcium and Ammonium, $Ca''(NH^4)AsO^4 + 6H^2O$, is produced, accord-
(Schw. J. xii. 285), by mixing a hot solution of arsenic acid in excess
vith nitrate of calcium, and crystallises on cooling in tables arranged
he solutions are mixed cold, the salt is precipitated as a powder. Any
that may be present remains dissolved. Another salt $Ca''(NH^4)^2H^2As^2O^8$
adding ammonia in excess to a solution of dicalcic arsenate in nitric
ulent precipitate, soon changing to a mass of needle-shaped crystals. If
nmonia be added to precipitate a portion of the salt, and the remaining
at rest, the same salt is obtained in crystals belonging to the regular
herefore dimorphous. (Baumann.)

senate, $2Ce''O.As^2O^5$ (?), is a white powder insoluble in water, but
arsenic acid as an acid salt, which dries up to a vitreous mass.
nd Berzelius.)

rsenate.—*Chromic* salts yield with arsenate of potassium an apple-
te.

of Cobalt.—The *cobaltic* salt is a brown precipitate, obtained by
e of potassium to a solution of cobaltic hydrate in acetic acid.
rsenate.—The *tricobaltous salt* occurs in red crystals, as *cobalt-bloom*,
(Kersten), a secondary product formed by the weathering of cobaltine
LOOM): and is obtained artificially as a reddish powder by precipi-
alts with trisodic arsenate.

nate of cobalt, known in commerce as *Chaux métallique*, is prepared:
carbonate of potassium to a solution of cobalt-glance in nitric acid or
long as a white precipitate of ferric arsenate continues to form, then
reating the filtrate with more carbonate of potassium to precipitate
ate.—2. By fusing cobalt-glance with twice its weight of crude potash
artz-sand, exhausting the fused mass with water, which takes up sul-
sium, together with arsenic, iron, and potassium, and again fusing the
vith potash, whereby a blue slag is obtained, which is used for the pre-
alt, and a pure regulus of arsenide of cobalt, which, by careful roasting,
to the required basic arsenate.

obtained by either of these processes is a reddish powder, which dis-
onia with bluish-red, or in hydrochloric acid with red colour. Caustic
the arsenic acid and leaves a blue protoxide of cobalt, which, when
or 2 pts. of alumina yields a fine blue pigment.

melting *Chaux métallique*, prepared in the wet way, in a porcelain fur-
a mass, the cavities of which contained deep blue prisms, yielding a
powder, easily soluble in acids, and consisting of $4Co''O.As^2O^5$.

ous salt is not known. The *monocobaltous* salt is obtained by evaporat-
ne solution of cobaltous hydrate in excess of arsenic acid.

f Copper, $Cu^3As^2O^8$, is obtained as a green powder by precipitating
pper with disodic arsenate, the liquid at the same time becoming acid.
ogether with the precipitate, be mixed with a sufficient quantity of
solve the precipitate, and the solution be then left to evaporate, crystals
onsisting of $Cu''(NH^4)^4As^2O^8 + 2(NH^4)HO$, which are permanent in
ary temperatures, but are decomposed by exposure to sunshine, or by
of 300° C., ammonia and water first passing off, and arsenious oxide
gher temperatures.

arsenates of copper occur as natural minerals, viz. $4Cu''O.As^2O^5$,
1 at. water as *olivenite*, with $7H^2O$ as *euchroite*, and with $10H^2O$
also $5Cu''O.As^2O^5$, occurring with $2H^2O$ as *erinite*, with $5H^2O$ as
vith $10H^2O$ as *leirochroite* (*Kupferschaum*).

f Iridium.—Brown precipitate formed on adding arsenate of sodium
ridium, and heating.

of Iron.—A *ferric arsenate*, $2Fe^2O^3.3H^2O.3As^2O^5 + 9Aq$, or
$^4)^3 + 9Aq$, is obtained by precipitating ferric chloride with disodic
vhite powder, which turns red and gives off water when heated. At a
vs slightly, and acquires a more yellowish tint. It dissolves in hydro-
nitric acid, separating as a white powder on evaporation. It is
etic acid and in ammoniacal salts. Aqueous ammonia dissolves it
hen recently precipitated, slowly after drying. The solution when
ves a ruby-red, transparent, fissured mass, consisting of *ammonio-ferric*
e in ammonia, but decomposed by pure water, which extracts arsenate

of ammonium, together with the undecomposed portion of the salt, and leaves ferri arsenate. The ammoniacal solution remains clear when mixed with ferrocyanide potassium, but on addition of an acid yields Prussian blue. When diferro arsenate is oxidised with nitric acid and ammonia is added in excess, a precipitate formed consisting of $Fe^2O^3.As^2O^5$, or $(Fe^2)^{vi}(AsO^4)^2$, insoluble in ammonia. Potas in large excess extracts part of the acid, leaving a compound of 7 pts. arsenic ac (anhydrous) with 79 pts. ferric oxide, corresponding to the formula $16Fe^2O^3.As^2O^5$ $24H^2O$ (Berzelius). On heating this salt to redness, bright incandescence tak place, but no arsenious oxide is given off.

Iron-cinder is a native ferric arsenate containing $2Fe^2O^3.As^2O^5 + 12H^2O$; *scorodi* is $Fe^2O^3.As^2O^5 + 4H^2O$ or $(Fe^2)^{vi}(AsO^4)^2 + 4H^2O$; *cube-ore* is a *ferroso-ferric arsena* $= FeO.Fe^2O^3.As^2O^5 + 6H^2O$; *pittizite* or *brown iron ore* is a ferric arsenate, 2Fe $As^2O^5 + 12H^2O$, combined, or perhaps only mixed, with ferric sulphate and water.

b. Ferrous Arsenate is obtained by precipitation as a white powder, which assum a dirty green colour when exposed to the air.

Arsenate of Lead.—The *triplumbic* salt, $Pb^3As^2O^8$, is prepared by dropping solution of a lead-salt into excess of disodic arsenate, or by digesting the diplumbi salt with ammonia. When heated, it turns yellow and cakes together, but does no melt. Insoluble in ammonia and ammoniacal salts. A *diplumbic* salt, $2Pb''O.As^2O$ or $Pb^2As^2O^7$, is precipitated on mixing a solution of nitrate of lead with arsenic aci or with less than the equivalent quantity of di-ammonic, dipotassic, or disodi arsenate. It is a white crystalline powder, insoluble in water and in acetic aci soluble in nitric and in hydrochloric acid.

Arseno-chloride of Lead.—In many varieties of *pyromorphite*, $PbCl^2.3Pb^3P^2O^8$, th phosphorus is more or less replaced by arsenic.

Arsenate of Magnesium.—The *trimagnesic* salt, $Mg^3As^2O^8$, is formed by pre pitating sulphate of magnesium with disodic arsenate, or by boiling the dimagnes salt for a long time with a strong solution of arsenate of sodium.—The *magnesi monohydric* salt, $2Mg''HAsO^4 + 13H^2O$ (Graham), is formed as a white insolubl precipitate on mixing the dilute solutions of 3 pts. sulphate of magnesium, and 5 pt disodic arsenate. In the recent state, it dissolves easily in nitric acid, but it i insoluble in acids after ignition. The *magnesio-tetrahydric* salt dissolves readily i water, and dries up to a gummy mass.

Arsenate of Magnesium and Ammonium, $Mg''(NH^4)AsO^4 + 6H^2O$, is obtained as crystalline precipitate by adding arsenic acid strongly supersaturated with ammon to a solution of a magnesium-salt mixed with sal-ammoniac. At 100° C. it gives o $\frac{11}{12}$ of its water (44·28 per cent.), together with ammonia and a certain portion arsenic. Like the corresponding phosphate, it is almost insoluble in water containin ammonia, or in sal-ammoniac, and is therefore well adapted for the estimation arsenic acid, and for separating that acid from arsenious acid. (H. Rose, p. 367.)

An *arsenate of Magnesium and Calcium*, containing $2(Ca''HAs^2O^4.Mg''HAsO^4)$ $Ca^3As^2O^8.Mg^3As^2O^8 + 10H^2O$, occurs native as *picropharmacolite*.

Arsenate of Magnesium and Potassium, $Mg''KAsO^4$, is produced by fusing arsenat of magnesium with excess of carbonate of potassium, and adding 1 at. hydrat of potassium: it is easily decomposed by water. The corresponding *sodium-salt* i obtained in like manner.

Arsenate of Manganese, $Mn''HAsO^4$, is obtained by saturating arsenic aci with recently precipitated carbonate of manganese.

Arsenate of Manganese and Ammonium, $Mn''(NH^4)AsO^4 + 6H^2O$.—Reddish-whit precipitate, gummy at first, afterwards becoming crystalline: obtained like the corresponding magnesium-salt.

Arsenates of Mercury.—A *mercuric arsenate* is obtained as a yellow precipitat on adding arsenic acid to mercuric nitrate, or arsenate of sodium to mercuric chlorid The same yellow salt is produced, with volatilisation of arsenious oxide, when arseni oxide is heated with mercury.

Di-mercurous arsenate, $2Hg^2O.H^2O.As^2O^5 + H^2O$, or $(Hg^2)''.H.AsO^4 + \frac{1}{2}H^2O$, i obtained by dropping mercurous nitrate into a strong solution of arsenic acid, as white precipitate, which turns red in drying. When, on the other hand, arseni acid or arsenate of sodium is added to the mercurous solution, a double salt of arsenat and nitrate of mercurosum is first formed; but it quickly decomposes, especially i heated, assuming a yellow, orange, red, and ultimately purple tint. When either o these precipitates is dissolved in warm nitric acid, and the acid is gradually neutralise with ammonia, a black precipitate is formed, which turns red when heated for some time.

Dimercurous arsenate is composed of fine needles, sometimes brown-red, sometime purple-red. When dried at 100° C., and then more strongly heated, it first gives of a little water, then mercury, and leaves yellow mercuric arsenate, which, at a higher temperature, is resolved into mercury, arsenious oxide, and free oxygen. With cold concentrated hydrochloric acid, it yields a solution of arsenic acid, and a residue of calomel, which is resolved by boiling into mercury and soluble mercuric chloride. It is converted into mercuric arsenate by boiling with nitric acid, but dissolves unchanged in that acid when cold, the solution being precipitated by ammonia. It dissolves slightly in aqueous nitrate of ammonium, and separates on evaporation with fine red colour and crystalline structure. It is quite insoluble in water, acetic acid, and ammonia. (Simon, Pogg. Ann. xli. 424.)

Monomercurous arsenate, $Hg^2O.As^2O^5$, is produced by boiling mercuric oxide, or the di-mercurous salt, to dryness with aqueous arsenic acid, triturating the dry mass when cold with water, washing the powder, and drying it over the water-bath, whereby the whole of the water is expelled. It is white and amorphous, gives off mercury at a red heat, and leaves mercuric arsenate, which then undergoes further decomposition. By careful addition of potash, it is converted into the dimercurous salt. With hydrochloric acid and with boiling nitric acid, it behaves like the dimercurous salt. In cold nitric acid it dissolves less abundantly than the latter, and on heating with gradual addition of ammonia, it yields a precipitate of the dimercurous salt. It is insoluble in water, acetic acid, and alcohol. (Simon.)

A double salt, consisting of *arsenate* and *nitrate of mercurosum*, $Hg^4As^2O^7.Hg^2N^2O^6$, is obtained, when water is carefully poured upon an equal volume of a strong solution of mercurous arsenate in moderately strong nitric acid, and an equal volume of aqueous ammonia then added, without allowing the liquids to mix. The double salt is then gradually deposited in white nodules and needles. If the mercurous nitrate be mixed with a very small quantity of nitric acid, the compound is obtained in the form of powder. (Simon.)

Arsenate of Molybdenum.—*Molybdous Arsenate* is a grey precipitate, produced by mixing molybdous chloride with arsenate of sodium. The precipitate redissolves at first, but afterwards becomes permanent.

Arseno-molybdic Acid.—Arsenic and molybdic acids digested together yield a colourless acid solution, and a lemon-yellow basic salt, insoluble in water. The solution evaporated to a syrup, yields colourless crystals, which when treated with alcohol, first yield white flocks, and then dissolve.

Arseno-molybdate of Ammonium.—On adding arsenic acid to a solution of molybdate of ammonium and heating to 100° C., a yellow precipitate is formed, similar to that produced by phosphoric acid. It contains 7 per cent. arsenic, and appears to be analogous to phospho-molybdate of ammonium. (See PHOSPHORIC ACID.)

Arsenate of Nickel, $Ni^3As^2O^8$, occurs as *nickel-bloom*, and is obtained by double decomposition as an apple-green crystalline powder, insoluble in water, soluble in arsenic acid and in other strong acids, also in ammonia; from the latter solution potash throws down hydrate of nickel free from arsenic.

Arsenate of Palladium.—Light yellow precipitate obtained by heating together the solutions of neutral nitrate of palladium and arsenate of sodium.

Arsenate of Platinum.—Light brown powder soluble in nitric acid, obtained by precipitating platinic nitrate with arsenate of sodium.

Arsenate of Potassium.—The *tripotassic* salt, K^3AsO^4, is obtained, by mixing aqueous arsenic acid or the neutral salt with potash-ley, and strong concentration, in small needles, which deliquesce quickly in the air. The *dipotassic salt*, K^2HAsO^4, is a deliquescent non-crystalline mass, produced by saturating arsenic acid with potash, or by fusing arsenious oxide with hydrate of potassium.

The *monopotassic salt*, KH^2AsO^4 (Macquer's *arsenikalisches Mittelsalz*), is prepared: 1. By deflagrating arsenious oxide with an equal weight of nitre, dissolving the fused mass in water, and leaving the solution to crystallise.—2. By mixing aqueous carbonate of potassium with such a quantity of arsenic acid, that the solution reddens litmus-paper but the redness disappears as the paper dries, and then evaporating.—3. A mixture of potash-ley and arsenic acid neutral to vegetable colours, deposits the monopotassic salt when partially evaporated, the alkaline dipotassic salt remaining in solution (Mitscherlich). Monopotassic arsenate is isomorphous with the corresponding phosphates of potassium and ammonium, and with monammonic arsenate. The crystals have a specific gravity of 2·638; they are permanent in the air, and give off but little water, even at 288° C., but at a red heat they melt, give off water, and are converted into a thin liquid, which on cooling solidifies into a white mass, cracked in all directions. They dissolve in 5·3 pts. of water at 6° C., forming a solution of specific gravity, 1·1134; they are much more soluble in hot water, but insoluble in alcohol. The aqueous solution reddens litmus, but the redness disappears on drying

It does not precipitate the salts of barium, calcium, magnesium, or the other earth metals.

Arsenate of Rhodium.—Yellowish-white precipitate formed by heating arsenat of sodium with chloride of rhodium and sodium.

Arsenate of Silver.—The *tri-argentic salt*, Ag^3AsO^4, is the only one that can b obtained by precipitating nitrate of silver with soluble arsenates; it is a dark brow precipitate which melts to a brown-red glass when heated, is converted into chloride o silver by hydrochloric acid, dissolves in acetic acid and aqueous ammonia, and when heated in sulphate, nitrate and succinate of ammonium. It dissolves also in aqueous arsen acid, and the solution, if left to evaporate, deposits the *monargentic* salt, AgH^2AsO Both this salt and the mother-liquor from which it has separated, are decomposed b water, yielding the brown triargentic salt.

The triargentic salt treated with sulphuric acid yields by evaporation a double sal $Ag^4As^2O^7.Ag^2SO^4$, which is decomposed by water and by dilute sulphuric aci (Setterberg.)

Arsenate of Sodium.—The *trisodic salt*, $Na^3AsO^4 + 12H^2O$ is prepared by fusin 1 at. of the disodic salt with carbonate of sodium, or by mixing the aqueous solutio of arsenic acid with excess of carbonate of sodium, and evaporating to a small bul The salt then crystallises almost completely, the excess of soda remaining dissolv The crystals are right rhombic prisms permanent in the air; they have an alkalin taste, melt at 86° C., and dissolve in $3\frac{1}{2}$ pts. of water, the solution as well as th ignited salt absorbing moisture from the air. The *disodic salt*, $Na^2HAsO^4 + 12H$ separates from a solution of arsenic acid slightly supersaturated with carbonate o sodium, and left to evaporate below 18° C., in large efflorescent crystals isomorphou with ordinary phosphate of sodium. By leaving a more concentrated solution t crystallise at 20° C. or above, crystals are obtained belonging to the monoclinic system containing 14 at. water, and not efflorescent. Both kinds of crystals give off th whole of their crystallisation-water, at 200° C., melt easily at a higher temperature and give off their basic water, leaving the anhydrous salt, $2Na^2O.As^2O^5$, or Na^4As^2 this anhydrous salt, however, recovers its basic water when redissolved. Accordin to Setterberg, a salt with 26 at., water of crystallisation separates from a solutio cooled to 0° C.

The *monosodic salt*, NaH^2AsO^4, is formed when arsenic acid is added to carbonat sodium till the solution no longer precipitates chloride of barium; it crystallises ou after a while in the cold. It is more soluble than the disodic salt, and forms larg crystals isomorphous with the corresponding phosphate.

Arsenate of Sodium and Ammonium, $Na(NH^4)HAsO^4 + 4H^2O$, is obtained by mixing the solutions of the di-ammonic and disodic salts, in crystals exactly resemblin those of the corresponding phosphate (microcosmic salt). When heated to redness they leave monosodic arsenate. (Mitscherlich.)

Arsenate of Sodium and Potassium, $KNaHAsO^4 + 16H^2O$. (Mitscherlich).—Obtained by neutralising the monosodic salt with carbonate of potassium. The crystals contain, according to Mitscherlich's analysis, 43·88 per cent. water, the preceding formula requiring 44·16 per cent.; but as they appear to be ismorphous with the disodic salt containing 14 at., L. Gmelin (Handbook iv. 299) considers it probable that they also contain the same quantity of water.

Arseno-fluoride of Sodium, $Na^3AsO^4.NaF + 12H^2O$.—Prepared by gradually introducing a mixture of 1 pt. arsenious oxide, 4 pts. carbonate of sodium, 3 pts. nitrate of sodium, and 1 pt. fluor-spar. into a red-hot crucible, and ultimately heating to complete fusion. On boiling the fused mass with water and filtering, the double salt crystallises out in regular octahedrous, exactly like common alum. They have a specific gravity of 2·849 at 21° C., dissolve in 9·5 pts of water, at 25° C., and in 2 pts. at 75° C. (Briegleb, Ann. Ch. Pharm. xcvii. 95.)

Arsenosulphate of Sodium.—A solution of 3 at. Na^2HAsO^4, mixed with 1 at. sulphuric acid, yields crystals containing $Na^8As^6O^{19}.2Na^2SO^4$, or $4Na^2O.3As^2O^5 + 2(Na^2O.SO^3)$; their solution slightly reddens litmus, but still turns turmeric brown (Mitscherlich). By dissolving sulphate of sodium and disodic arsenate together in equivalent proportions, or by heating anhydrous disodic arsenate in a current of sulphurous anhydride (half the arsenic acid being then reduced to arsenious acid, which volatilises), and subsequent recrystallisation, a salt is obtained, composed of $Na^2SO^4.Na^4As^2O^7$, which does not alter by exposure to the air, and fuses more easily than either of its component salts. (Setterberg.)

Arsenate of Strontium, $Sr''HAsO^4$.—Resembles the barium-salt. By precipitating its solution in nitric acid with excess of ammonia, a double salt is produced containing $Sr''(NH^4)AsO^4 + \frac{1}{2}H^2O$.

of Thorinum, is obtained by double decomposition, as a white flocculent
nsoluble in water and in the aqueous acid.

of Titanium.—Arsenic acid added to solution of titanic oxide, throws
locks, which dry up to vitreous masses, and are soluble in free titanic
as in arsenic acid.

s of Tin.—The *stannic* salt, $2SnO^2.As^2O^5 + 10H^2O$, is precipitated as
mass when a mixed solution of stannate and excess of arsenate of sodium
h excess of nitric acid. It is transparent when dry, and gives off all its
° C. (Haeffely, Phil. Mag. [4] x. 290.)
Irsenate is a white precipitate obtained by adding arsenic acid to stannous
cetate. Tin heated with aqueous arsenic acid eliminates hydrogen and
inous mass.

s of Uranium.—*Uranic arsenate*, or *Arsenate of Uranyl*, $(U^2O^2)''HAsO^4$
formed by precipitating uranic acetate with arsenic acid, or uranic nitrate
e of sodium. It is a yellow precipitate which gives off its water at

anic arsenate, $(U^2O^2)''NaAsO^4 + \frac{5}{2}H^2O$, is obtained by mixing a solution of
te with trisodic arsenate; and by boiling uranic arsenate with solution
ate of copper (obtained by digesting verdigris with water), a green *cupro-*
ate is formed, containing $(U^2O^2)^2Cu''As^2O^8 + 8Aq$. (Werther.)
Irsenate, $U''HAsO^4 + \frac{3}{2}H^2O$, is a green precipitate obtained by treating
oride with disodic arsenate. It dissolves in hydrochloric acid, and the
ed with excess of ammonia yields a very bulky precipitate of *tri-uranous*
As^2O^8. (Rammelsberg, Pogg. Ann. lix. 96.)

s of Vanadium.—A solution of vanadic hydrate in excess of arsenic
by evaporation, a crust of blue crystalline granules, containing 1 at.
e (VO^2) to 1 at. anhydrous arsenic acid. It dissolves very slowly in
asily in hydrochloric acid. A more basic salt is obtained as a syrupy
with crystals of the preceding salt, by evaporating a solution of arsenic
d with vanadic oxide.
tion of the crystalline compound in nitric acid be evaporated till nitrous
o escape, a yellow powder is deposited, which is a compound of vanadic
nhydrides, $2V^2O^5.3As^2O^5$.

of Yttrium.—The *di-yttric* salt obtained by precipitation is a white
r, which dissolves in nitric acid, and separates therefrom in crystalline
nitric acid solution supersaturated with ammonia yields the *tri-yttric* salt.
ves in excess of arsenic acid, but the solution when heated deposits the

of Zinc.—Acetate of zinc treated with arsenic acid or arsenate of
ls a white precipitate, which dissolves in excess of arsenic acid, and se-
aporation in cubical crystals of an acid salt. Zinc dissolves in aqueous
with evolution of arsenetted hydrogen, and deposition of metallic arsenic
rown solid arsenide of hydrogen. When zinc and arsenic oxide are fused
rge quantity of arsenic is reduced, with slight detonation.
Irsenate, $Zn^3As^2O^8 + 8H^2O$, occurs as *Köttigite* in the Daniel cobalt mine
berg in Saxony, forming monoclinic crystals, or crusts with crystalline
Specific gravity 3·1. Hardness 2·5—3. It is of light carmine or peach-
ur, translucent, and gives a reddish-white streak. The zinc is partly
cobalt and nickel. Analysis 37·2 per cent. As^2O^5, 30·5 ZnO, 6·9 CoO,
ith trace of lime, and 23·4 water. (Köttig, J. pr. Chem. xlvii. 183;
ibid. 256.)
f zinc added to a solution of arsenate of sodium containing ammonia pro-
pitate of trizincic arsenate, which soon changes to a crystalline compound
ccording to Bette, $Zn^3As^2O^8.2NH^3.3H^2O$ (?).

of Zirconium.—White precipitate insoluble in water.

C, OXYBROMIDE OF. *Bromarsenious Acid.* AsBrO.—Arsenious
ves easily and abundantly in fused arsenious bromide, forming a somewhat
coloured liquid, which does not solidify so quickly as the pure bromide.
l be distilled till it becomes rather thick and then allowed to cool to about
F. ?) it separates into two layers, the lower of which is a soft dark-coloured
ting of the oxybromide AsBrO, while the upper, which is very viscid, is a
the oxybromide with arsenious oxide, probably $6AsBrO.As^2O^3$; both these
ecomposed by heat, giving off bromide of arsenic (W. Wallace, Phil. Mag.
). An oxybromide of arsenic is likewise formed by the action of water on

the bromide (Serullas). When bromide of arsenic is boiled with a quantity of wate containing hydrobromic acid not sufficient to dissolve it, the undissolved portion i converted into oxybromide. A cold solution of bromide of arsenic in water containin hydrobromic acid, yields, by evaporation over sulphuric acid, thin white pearly crystals consisting of hydrated oxybromide, $2AsBrO.3H^2O$. A solution of bromide of arseni in water, prepared at the boiling heat, deposits on cooling crystals of arsenious oxide but if the water contains a large quantity of hydrobromic acid, the solution deposits o cooling, white flocks of a compound, which after drying between filter-paper, consist of $2AsBrO.3As^2O^3 + 12H^2O$.—When bromide of ammonium is added to a cold con centrated solution of bromide of arsenic, six-sided tables are slowly deposited, consisting mainly of anhydrous bromide of arsenic. (Wallace, *loc. cit.*)

ARSENIC, OXYCHLORIDE OF. *Chlorarsenious Acid.* AsClO, or $AsCl^3.As^2O$ —Pulverised arsenious oxide added in successive portions to boiling chloride of arseni continues to dissolve till the liquid contains 2 at. chloride to 1 at. oxide. The sam solution is obtained by passing dry hydrochloric acid gas into a vessel containing dr arsenious oxide till the latter is dissolved: great heat is evolved during the reaction On distilling the solution obtained by either process, till it begins to froth, and leavin the residue to cool, oxychloride of arsenic separates as a viscid, translucent, brownis mass, which fumes slightly in the air, and absorbs oxygen from it, froths when strongl heated, giving off chloride of arsenic, and at the subliming temperature of arseniou oxide, leaves a hard vitreous residue, consisting of $AsClO.As^2O^3$.

Oxychloride of arsenic is likewise produced when chloride of arsenic is treated wit a quantity of water not sufficient to dissolve it completely. A solution of chloride o arsenic in the smallest possible quantity of water ($8H^2O$ to $1AsCl^3$) deposits, afte some days, small, white, needle-shaped crystals, grouped in stars or like prehnite, an consisting of $AsClO.H^2O$; the mother-liquor yields an additional quantity when mixe with chloride of sodium.

Oxychloride of arsenic unites with metallic chlorides. By mixing aqueous chlorid of arsenic with a quantity of hydrochloric acid sufficient to prevent the separation o oxychloride, and then adding a lump of sal-ammoniac, crystals of that salt separat out at first, and after a few days, fibrous needles of the compound $AsClO.2NH^4C$ apparently containing ½ at. H^2O, which is given off when the crystals are left over sul phuric acid. (Wallace, Phil. Mag. [4] xvi. 358.)

ARSENIC, OXYIODIDE OF. $As^8I^2O^{11} = 2AsIO.3As^2O^3$.—A hot aqueous solu tion of arsenious iodide deposits, when concentrated by boiling, fine red needles of th anhydrous iodide; but if left to cool slowly, it deposits thin pearly laminæ, which afte drying between bibulous paper, are composed of $2AsIO.3As^2O^3 + 6H^2O$, and give off al their water over sulphuric acid. They are decomposed by water, and when heate yield a sublimate chiefly consisting of iodide of arsenic, while arsenious oxide remain behind (Wallace, Phil. Mag. [4] xvii. 122). The formation of this compound ha previously been observed by Plisson and by Serullas and Hottot, who regarded it a a compound of arsenious oxide with arsenious iodide. (Gm. iv. 282.)

ARSENIC, OXYSULPHIDE OF. See SULPHOXARSENATE OF POTASSIU (p. 395).

ARSENIC, SULPHIDES OF. The sulphides of arsenic are more numerou than the oxides. There are three well-defined sulphides, As^2S^2, As^2S^3, and As^2S^5 [o AsS^2, AsS^3, and AsS^5, if $S = 16$], all of which act as sulphur-acids. The first tw occur as natural minerals, *realgar* and *orpiment*, and may also be obtained in the fre state by artificial processes; the third is known only in combination. Besides thes compounds, there is a *subsulphide*, $As^{12}S$ (?), which remains as a brown powder whe the disulphide As^2S^2 is digested with caustic alkalis; and, according to Berzelius, *persulphide*, As^2S^{18}, obtained in yellow crystalline scales, by mixing a solution o dipotassic or disodic sulpharsenate with alcohol, and evaporating to about two-thirds but the product thus obtained is most probably a sulpharsenate with excess of sulphur When arsenious oxide is fused with sulphur, sulphurous anhydride is evolved, and sulphide of arsenic containing excess of sulphur remains. On distilling this residue sulphur passes over, accompanied by a continually increasing quantity of arseni Much of the ordinary sulphur of commerce is a compound of this nature.

DISULPHIDE OF ARSENIC. As^2S^2. *Realgar*, *Red Orpiment*, or *Ruby Sulphur* *rothes Rauschgelb*, *Arsenic sulphuré rouge*, *Risigallo*; *Sandaraca* of Pliny an Vitruvius; *σανδαράκη* of Theophrastus and Dioscorides. In combination: HYPOSULPH ARSENIOUS ACID.—This compound occurs native as realgar, crystallised in oblique rhombic prisms of the monoclinic system, having an orange-yellow or aurora-red colour, resinous lustre, and more or less translucent: streak varying from orange- red to aurora-red; fracture conchoïdal, uneven; sectile. Specific gravity = 3·4 to 3·5

1·5 to 2. It is found accompanying ores of silver and lead, at Andreas-
Harz, Kapnik and Nagyag in Transylvania, Felsöbanya in Hungary,
l in Bohemia, and Schneeberg in Saxony. At Tajowa in Hungary, it
ds of clay; at St. Gothard imbedded in dolomite; near Julamerk in
also in the Vesuvian lavas, in minute crystals. Strabo speaks of a mine
at Pompeiopolis, in Paphlagonia. (Dana.)

of arsenic may be prepared by melting metallic arsenic with sulphur or
sulphur with arsenious oxide, in the required proportions. As thus
is transparent and of a ruby-colour, easily fusible, and crystalline after
from fusion. An impure product is prepared on the large scale by heat-
bliming apparatus a mixture of arsenical pyrites and iron-pyrites, and
product with arsenic or sulphur, according as a darker or lighter colour is
is commercial product is amorphous, usually brown-red, opaque, and of
position, generally containing arsenious oxide. It is used as a pigment,
o much now as formerly.

of arsenic burns in the air with a blue flame, forming sulphurous and
ides. When deflagrated with nitre, it produces a bright white light.
fire is a mixture of 24 pts. nitre, 7 pts. sulphur, and 2 pts. realgar. The
eated with nitric acid, yields arsenic acid and free sulpur. With strong
d, it forms sulphurous and arsenious acids. When it is digested in fine
potash-ley, part dissolves and there remains a brown powder consisting

ARSENITES.—These are sulphur-salts formed by the mixing of disulphide
th basic sulphides. They are for the most part sparingly soluble in
little that is known of them is due to the researches of Berzelius.

nium-salt is deposited in small dark brown granules on the sides of a
in which neutral sulpharsenite of ammonium is kept for a long time. It
onia-gas, but gives it off again on exposure to the air.

arsenite of Potassium.—The colourless liquid obtained by boiling trisul-
nic with moderate concentrated carbonate of potassium, deposits in the
hours, brown-red flocks of the salt $2K^2S.As^2S^3$, or $K^4As^2S^4$. If this com-
hed with a small quantity of cold water till it swells up to a jelly, and
with more water, the greater part dissolves, forming a red solution of
$^2S.As^2S^3$, and leaving an insoluble dark-brown powder consisting of
which melts easily when heated, and solidifies on cooling to a transparent
s. The basic salt $3K^2S.As^2S^3$ remains perfectly soluble in water, even
e drying.

hyposulpharsenites resemble those of potassium.

osulpharsenites are obtained by precipitation. The *barium* and *calcium*
brown; the *magnesium-salt* is brown; the *manganese-salt* dark red.

IDE OF ARSENIC, or ARSENIOUS SULPHIDE. In combination:
OUS ACID. As^2S^3, or AsS^3. *Orpiment, Yellow Sulphide of Arsenic, Gelbes*
Risigallum, Auripigmentum (Vitruvius); *Arsenicum* (Pliny); *'Αρσένικον*
; *'Αῤῥένικον* (Theophrastus).—This sulphide occurs native in rhombic
ging to the trimetric system, easily splitting parallel to ∞P̆∞ into thin
e. They are translucent, of lemon-yellow colour, inclining to orange-yellow,
ustre on the cleavage-faces, resinous elsewhere; powder lemon-yellow;
y 3·459 (Karsten), 3·48 (Mohs, Haidinger), 3·4 (Breithaupt).

of arsenic is obtained in the pure state by passing hydrosulphuric acid
ution of arsenious acid or an arsenite acidulated with one of the stronger
us prepared, it has a fine lemon-yellow colour, becoming darker by heat,
an orange-yellow powder: it melts easily and volatilises at a higher

trisulphide is prepared on the large scale by subliming 7 parts of pulve-
s oxide with 1 pt. of sulphur. It always contains more or less oxide,
o convert that compound completely into trisulphide requires 7·3 pts. of
pts. of the oxide: hence this preparation is much more poisonous than
icial sulphide or the native sulphide. It was formerly much used as a
r the name of *King's yellow*, but is now almost entirely superseded by
. The arsenious oxide may be extracted from it by boiling with water,
aqueous acids, or cream of tartar.

ulphide is also used in calico printing, the pattern being printed with a
ontaining arsenious acid, and then passed through water containing
c acid. A solution of orpiment in potash-ley is used in dyeing as a de-
nt, especially for reducing indigo. A paste composed of slaked lime,
water, is employed by some nations as a depilatory for removing the

beard; but it is a dangerous preparation, and, according to Böttger may be replaced for this purpose by sulphydrate of calcium.

Decompositions.—1. Arsenious sulphide, like all the other sulphides of arsenic, is converted by *oxidising agents* into oxides of sulphur and arsenic. When it is fused with *acid sulphate of potassium*, sulphurous oxide (SO^2) is given off, and arsenite of potassium remains mixed with neutral sulphate.—2. Exposed to the action of *chlorine gas*, it becomes heated, and deliquesces to a brown liquid consisting of a sulphochloride of arsenic, $As^2Cl^6S^3$ (H. Rose).—3. The vapour of arsenious sulphide passed over red-hot *iron*, *silver*, and other metals, is decomposed, yielding a metallic sulphide and free arsenic, which, if the other metal is in excess, unites with it.

4. When the vapour is passed over red-hot lime, arsenic is separated, and arsenate of calcium is produced, together with sulphide of calcium.

5. Arsenious sulphide heated with *carbonate of potassium* or *sodium* in a glass tube, yields a mirror of arsenic, together with sulpharsenate and arsenate of the alkali-metal. If the mixture is heated in an atmosphere of *hydrogen*, or with addition of *charcoal*, the arsenical mirror is increased by the arsenic reduced from the arsenate; the sulpharsenate remains undecomposed. (H. Rose, Pogg. Ann. xc. 565.)

6. When arsenious sulphide is heated in a test-tube with a mixture of *alkaline carbonate* and *cyanide of potassium*, the whole of the arsenic is reduced, according to Fresenius; only part of it, according to H. Rose, because the sulphur-salt of arsenic formed at the same time resists the action of the cyanide of potassium. Hence arsenious sulphide fused with cyanide of potassium and excess of sulphur does not yield any arsenical mirror. The formation of the mirror may also be prevented by the presence of other easily reducible metals, which convert the arsenic into an arsenide, and do not give it up.

7. When arsenious sulphide is boiled with the solution of an *alkaline carbonate*, and the concentrated solution is filtered, a clear liquid is obtained, which deposits a brown powder, consisting of hyposulpharsenite of the alkali-metal, while a sulpharsenate remains in solution. A similar decomposition takes place when a soluble neutral sulpharsenite is treated with water.

8. Arsenious sulphide is readily dissolved by cold caustic potash, soda, or ammonia, undergoing exactly the same decomposition as antimonious sulphide under similar circumstances (p. 322), the oxygen of the alkali converting the arsenic into arsenious acid, while the alkali-metal unites with the sulphur, and the basic sulphide thus formed combines with the rest of the arsenious sulphide:

$$4As^2S^3 + 5K^2O = 3(K^2S.As^2S^3) + 2K^2O.As^2O^3$$

On adding an acid to this solution, no sulphuretted hydrogen is evolved, but the whole of the sulphur and arsenic are separated as arsenious sulphide:

$$3(K^2S.As^2S^3) + 2K^2O.As^2O^3 + 10HCl = 10KCl + 5H^2O + 4As^2S^3$$

SULPHARSENITES.—Arsenious sulphide unites with basic metallic sulphides in three different proportions, forming, with potassium, for example, the compounds $3K^2S.As^2S^3$ or K^3AsS^3, $2K^2S.As^2S^3$ or $K^4As^2S^5$, and $K^2S.As^2S^3$ or $KAsS^2$ [or $3KS.2AsS^3$, $2KS.AsS^3$, and $KS.AsS^3$.—Of these, the *dibasic* or *tetrametallic* salts are the most common, and are regarded as neutral or normal sulpharsenites.

The soluble sulpharsenites are prepared: 1. By igniting sulpharsenates out of contact with the air, 2 at. sulphur then escaping.—2. by dissolving arsenious sulphide in an alkaline sulphide or sulphydrate; in the latter case, sulphuretted hydrogen is evolved.—3. By dissolving arsenious sulphide in a cold solution of caustic alkali.—4. By dissolving arsenious oxide in an alkaline sulphydrate, in which case half of the alkali is converted into arsenite; *e. g.*:

$$As^2O^3 + 2KHS = KAsS^2 + KAsO^2 + H^2O.$$

The only sulpharsenites that are soluble in water are those of the alkali-metals, alkaline earth-metals, and magnesium, and even these are decomposed by water, unless the water is in considerable quantity. Hence the solutions cannot be evaporated to dryness without decomposition. The solutions are colourless or yellowish, tasting hepatic at first, and afterwards disgustingly bitter.—5. The sulpharsenites of the earth-metals and heavy metals are obtained by precipitating a solution of the corresponding compound of an alkali-metal, obtained by either of the methods 2, 3, 4, with a salt of the earth-metal or heavy metal. (Berzelius.)

The sulpharsenites are either yellow or red. Most of them, when ignited out of contact of air, give off all their sulphur-acid; others give up such a quantity that the residue contains 3 at. sulphur-base to 1 at. sulphur-acid; but the sulpharsenites of the alkali-metals, even those which contain equal numbers of atoms of base and acid, give off nothing when ignited. The alkali-metal compounds obtained by the first method

with a small quantity of water, and the dilute solutions obtained by
or 4, when they evaporate in the air, are resolved into brown hyposulph-
h is precipitated, and sulpharsenate which remains in solution; but the
is not complete till the solution is concentrated to the crystallising
atter salt. If the decomposed mass be digested in a large quantity of
iled, the whole is reconverted into sulpharsenite and redissolved. The
he barium, strontium, calcium, and magnesium salts, containing 1 at. base
deposit, on boiling, a portion of the arsenious sulphide; the ammonium,
dium, and lithium compounds remain undecomposed. On adding alcohol
s solution of a compound of 1 at. of arsenious sulphide with 2 at. of the
n alkali-metal, a compound containing 3 at. of sulphur-base is precipi-
compound containing 1 at. of sulphur-base remains in solution:

$$2(2K^2S.As^2S^3) = 3K^2S.As^2S^3 + K^2S.As^2S^3.$$

cipitated tribasic salt soon turns black, being resolved into hyposulph-
sulpharsenate. The potassium and sodium compounds exhibit this
the addition of alcohol, even when the solution contains nothing but
$3K^2S.As^2S^3$); but with the ammonium, barium, strontium, and calcium
not take place unless the solution contains dibasic salt ($2Ba''S.As^2S^3$). —
tions of sulpharsenites exposed to the air are decomposed by oxidation
in proportion to the excess of sulphur-base), depositing orpiment and a
und of disulphide of arsenic with the sulphur-base. Hydrated oxide of
to a solution containing a compound of sulpharsenious acid with the sul-
alkali-metal, decomposes that compound, yielding twelve-basic sulph-
pper, which remains undissolved, and a hyacinth-red solution, containing
rsenite and tribasic sulpharsenite of copper, and deposits the latter on the
ydrochloric acid. Perhaps in this manner:

$$S^3) + 27Cu''O = 2(12Cu''S.As^2S^3) + 3Cu''S.As^2S^3 + 3(3K^2O.2As^2O^3).$$

ed oxide of copper is in excess, the arsenious acid contained in the solu-
rted into arsenic acid, and the protoxide of copper reduced to sub-oxide.
silver in excess decomposes the solution, forming sulphide of silver and
nite:

$$KAsS^2 + 2Ag^2O = 2Ag^2S + KAsO^2.$$

enite of Ammonium, $2(NH^4)^2S.As^2S^3$. — The solution of arsenious
sulphide of ammonium or caustic ammonia yields, when mixed with
recipitate of this composition, which, however, soon turns brown. If
ixed with sulphydrate of ammonium, it deposits white feathery crystals of
t $(3NH^4)^2S.As^2S^3$. Finely divided arsenious sulphide absorbs 6½ per
onia-gas, but gives it up again when exposed to the air.

enite of Barium.—The solution of arsenious sulphide in sulphydrate of
up to a red-brown gummy mass of the neutral salt, $2Ba''S.As^2S^3$, perfectly
ter. Alcohol precipitates from the solution crystalline flakes of the basic
s^2S^3, which is likewise obtained by treating arsenious sulphide with excess
f barium.

enite of Bismuth, $2Bi^2S^3.As^2S^3$, is a red-brown precipitate, which
in drying. By fusion, a grey metallic-shining mass is obtained, con-
basic salt.

enite of Cadmium.—Cadmium-salts mixed with a saturated solution
sulphide in sulphide of ammonium, yield a yellow precipitate, $2Cd''S.As^2S^3$.
es orange-yellow when dry, and semifluid when heated, giving off part of
s sulphide, and leaving a fused grey compound containing a larger pro-
dmic sulphide.

enite of Calcium.—When orpiment is digested with milk of lime, and
is filtered from the arsenite of calcium, which forms at the same time, a
trate is obtained, which, by spontaneous evaporation, yields feathery
e basic salt $3Ca''S.As^2S^3$, surrounded by a brown syrup of the neutral salt
This syrup digested with an additional quantity of arsenious sulphide
and deposits a brown powder consisting of *hyposulpharsenite* of calcium,
The solution of the sulpharsenite containing excess of sulphide of calcium
lcohol, a white precipitate of the basic salt, containing $3Ca''S.As^2S^3 + 15Aq$.

senite of Cerium, $2Ce''S.As^2S^3$.—Yellow precipitate, which acquires a
r when dry, melts, and evolves part of the arsenious sulphide when heated,
asted gives up all its arsenic, and is completely converted into sulphate.

senite of Chromium, $2Cr^2S^3.3As^2S^3$.—Greyish yellow precipitate, greenish-yellow after drying. When heated, it melts and gives off part of arsenious sulphide, and is converted into chromic oxide by roasting.

Sulpharsenite of Cobalt, $2Co''S.As^2S^3$, is a dark brown precipitate, w becomes black in drying, dissolves in excess of the precipitant, and when ign in close vessels, leaves a residue having the composition of cobalt-glance.

Sulpharsenite of Copper.—A twelve-basic salt, $12Cu''S.As^2S^3$, remains un solved as a brown mass, when cupric hydrate is added to solution of monopot sulpharsenate, till the colour of the liquid is no longer altered. The *tribasic* $3Cu^2S.As^2S^3$, is precipitated in light brown flakes on adding hydrochloric acid to hyacinth-red solution obtained in the manner just mentioned. The neutral $2Cu^2S.As^2S$, is obtained by adding neutral sulpharsenite of sodium to a cupric sal a black-brown precipitate, which acquires a metal-grey aspect by trituration. W distilled, it first gives off sulphur, then arsenious sulphide, and leaves a tume metal-grey substance, probably consisting of cuprous hyposulpharsenite.

Sulpharsenite of Glucinum, $2G''S.As^2S^3$, is a yellow precipitate, formed, with evolution of sulphuretted hydrogen, on adding a neutral glucinum-salt to a solu of sulphide of sodium saturated with arsenious sulphide. Acids separate but h sulphuretted hydrogen from it, ammonia partly dissolves it, and leaves pure glucin

Sulpharsenite of Gold, $2Au^2S^3.3As^2S^3$.—Yellow precipitate, becoming da as it settles down, black when dry, and yielding by trituration a yellow-brown pow At a dull red heat, it melts, gives off part of the arsenious sulphide, and solidifies t transparent yellow-red mass, yielding by dry trituration a yellow-brown mass, wh however, by continued trituration under water, assumes a metallic lustre, a from reduced gold. To expel the whole of the arsenious sulphide requires a white heat.

Sulpharsenites of Iron.—The *ferric salt*, $2Fe^2S^3.3As^2S^3$, is an olive-gr precipitate, soluble in excess of the precipitating alkaline sulpharsenite, acquirin green colour when dry, and a fine yellow-green by trituration. It melts easily w heated, and decomposes at a red heat, leaving pure sulphide of iron. The *ferrous s* $2Fe''S.As^2S^3$, is a brown-black precipitate, also soluble in excess of the precipita grey-brown when dry, dark greenish after trituration. It is decomposed by he leaving pure sulphide of iron. The dried precipitate always contains ferric ox mixed with the preceding salt.

Sulpharsenite of Lead, $2Pb''S.As^2S^3$.—Red-brown precipitate. black when d melts to a brittle metallic-looking mass, a shining grey crystalline fracture, and yie ing a grey powder.

Sulpharsenite of Lithium resembles the potassium- and sodium-salts.

Sulpharsenite of Magnesium.—The aqueous solution evaporated, or coo to −5° C., becomes light brown, and deposits a brown powder consisting of hypos pharsenite of magnesium; then dries to a viscid mass, which ultimately solidif and is almost wholly soluble in water.

Sulpharsenite of Manganese.—Light red precipitate, becoming orange-yell when dry. Heated in close vessels, it gives off a considerable portion of the arsenio sulphide, and leaves a yellow-green compound, from which hydrochloric acid extra the manganese, with evolution of sulphuretted hydrogen, leaving a residue of arsenio sulphide.

Sulpharsenites of Mercury.—The neutral *mercuric salt*, $2Hg''S.As^2S^3$, is orange-red flocculent precipitate, which becomes white in presence of excess of mercu chloride, but retains its colour if the precipitant is in excess. It is dark brown whe dry, and gives a yellow powder. When heated, it yields a grey metallic-shining su limate of $Hg''S.As^2S^3$, which is translucent in thin films, and yields a yellow powd when finely ground. The *mercurous salt*, $2(Hg^2)''S.As^2S^3$, is a black precipitate, whi decrepitates with explosion when distilled, giving off mercury and yielding a sublima of mercurous hyposulpharsenite in black opaque metallic crusts, which yield a re powder.

Sulpharsenite of Molybdenum.—The solution of molybdic acid in hydrochlor acid forms with sulpharsenite of sodium, a dark brown powder, which becomes black i drying, and decomposes at a red heat, giving off arsenious sulphide and sulphur, an leaving disulphide of molybdenum, MoS^2.

Sulpharsenite of Nickel, $2Ni''S.AsS^3$, is a black precipitate, which, when distille easily gives off all its arsenious sulphide, and leaves yellow sintered sulphide of nicke

Sulpharsenite of Potassium.—The neutral salt, $2K^2S.As^2S^3$, is obtained b igniting the corresponding sulpharsenate ($2K^2S.As^2S^5$) till the excess of sulphur

It is a dark yellow mass, which becomes yellow on cooling. Treated with
elds a solution of basic sulpharsenate ($3K^2S.As^2S^3$) and a residue of
senite. When arsenious sulphide is dissolved at mean temperature in
phydrate of potassium, till all the sulphuretted hydrogen is eliminated,
contains an *acid sulpharsenite*, $K^2S.2As^2S^3$. This solution is decomposed
on, depositing brown hyposulpharsenite of potassium, $K^2S.AsS$. On mixing
with alcohol, a white precipitate of $3K^2S.As^2S^3$ is formed at first; but
mes brown and syrupy, and deposits the hyposulpharsenite. When car-
otassium is fused with arsenious sulphide till the excess of the latter is
ere remains a mass, consisting of $K^2S.As^2S^3$. This salt is decomposed by
acid salt, $K^2S.2As^2S^3$, dissolving, and a compound, still richer in arsenious
maining undissolved.

senite of Silver, $2Ag^2S.As^2S^3$, is a light brown precipitate, transparent
oming black during collection; when heated in the dry state, it melts and
t of the arsenious sulphide. The black fused mass yields a brown powder.
ulpharsenite of sodium is precipitated by a saturated solution of chloride
ammonia, a dark yellow precipitate is formed, containing $6Ag^2S.As^2S^3$.

senite of Sodium.—Strictly analogous to the potassium-salt.

senites of Tin.—The *stannous salt*, $2SnS.As^2S^3$, is a dark red-brown
infusible, but giving off part of its sulphur at high temperatures. The
$SnS^2.As^2S^3$, is a gummy yellow precipitate, which becomes orange-yellow

Sulpharsenite, $2U^2S^3.As^2S^3$, is a dingy yellow precipitate, which melts
ff part of its sulphur when heated, and, after exposure to a white heat,
y porous mass, still containing arsenious sulphide.

senite of Zinc, $2Zn''S.As^2S^3$.—Lemon-yellow precipitate, orange-yellow
gives off arsenious sulphide when heated, leaving a more basic compound,
her temperature, pure sulphide of zinc.

senite of Zirconium, $2Zr^2S^3.As^2S^3$.—Orange-yellow precipitate, quite
excess of the alkaline sulpharsenite.

ULPHIDE OF ARSENIC, OR ARSENIC SULPHIDE. In combination:
IC ACID. As^2S^5, or AsS^5.—A substance containing arsenic and sulphur
ortion is precipitated when a soluble sulpharsenate is decomposed by hy-
cid; but it appears to be rather a mixture of the trisulphide with free
When sulphuretted hydrogen is passed into an aqueous solution of arsenic
ur is first separated, and remains for a long time suspended in the liquid.
tate contains a very small quantity of trisulphide of arsenic, which may be
dilute ammonia, pure sulphur then remaining. The filtered liquid is then
tain arsenic acid, together with a small quantity of arsenious acid; and, if
hydrogen be then rapidly passed through it for a short time, a precipitate
le of arsenic is obtained. If this precipitate be separated by filtration, and
of the sulphuretted hydrogen continued, the liquid again becomes turbid
ation of sulphur, and, by repeating these operations, the whole of the
be precipitated as trisulphide. (H. Rose, Pogg. Ann. cvii. 186; H.
rch. Pharm. [2] xcvii. 23.)

de of arsenic corresponding to anhydrous arsenic acid, As^2O^5, does not
pear to exist in the free state. Nevertheless, the precipitate thrown down
m solutions of sulpharsenates has the composition of the pentasulphide,
dissolves completely in alkaline sulphides and in strong ammonia; dilute
owever, dissolves out the trisulphide and leaves the sulphur.

ENATES.—These salts may be regarded as compounds of pentasulphide of
basic metallic sulphides. Our knowledge respecting them is chiefly due
rches of Berzelius. They are for the most part *mono-*, *di*, or *tribasic*, a few
ly occurring of sulpharsenates with larger proportion either of sulphur-
hur-acid. Their general formulæ are:

onobasic or Monometallic . $M^2S.As^2S^5$ or $MAsS^3 = \left.\begin{matrix}\dot{As}S^2\\ M\end{matrix}\right\}S$ *

basic or Tetrametallic . $2M^2S.As^2S^5$ or $M^4As^2S^7 = \left.\begin{matrix}\overset{\cdots}{As^2}S^3\\ M^4\end{matrix}\right\}S^4$

ibasic or Trimetallic . $3M^2S.As^2S^5$ or $M^3AsS^4 = \left.\begin{matrix}\ddot{As}S\\ M^3\end{matrix}\right\}S^3$

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* For diatomic metals: $M''As^2S^6$, $(M'')^2As^2S^7$, and $(M'')^3As^2S^8$.

The tetrametallic salts are generally regarded as neutral; the monometallic as acid; the trimetallic as basic.

The sulpharsenates are prepared: 1. By passing sulphuretted hydrogen through the solution of an arsenate in water or in hydrochloric acid, thus:

$$K^3AsO^4 + 4H^2S = K^3AsS^4 + 4H^2O.$$

—2. By fusing orpiment with excess of sulphur and a caustic alkali or alkaline carbonate. —3. By digesting the trisulphide in an aqueous solution of a disulphide or polysulphide of alkali-metal.—4. By dissolving the pentasulphide ($As^2S^3 + 2S$) in a caustic alkali, or in an alkaline carbonate at the boiling heat. In this case an arsenate is formed at the same time.—5. Those sulpharsenates which are insoluble in water may be obtained by precipitation from the solution of an alkaline sulpharsenate.

The dry sulpharsenates of the alkali-metals are lemon-yellow; the others red or brown. They are permanent in the air. Those which are soluble taste hepatic at first, afterwards intensely bitter. The tribasic salts have a tendency to crystallise; the dibasic and monobasic salts are amorphous.

The trimetallic sulpharsenates of potassium, sodium, lithium, and barium may, if air be excluded, be heated almost to whiteness without decomposition; on cooling, they solidify to a yellow mass perfectly soluble in water. The tetrametallic and monometallic sulpharsenates of these metals give off sulphur when heated, and are converted into sulpharsenites. The silver- and mercury-salts (the latter of which sublimes) remain undecomposed at a red heat. The other tetrametallic and monometallic sulpharsenates are decomposed by ignition, first yielding sulphur and a red salt of sulpharsenious acid; and in many cases, the sulpharsenite is resolved by continued ignition into trisulphide of arsenic, which sublimes, and the sulphur-base, which remains behind. The calcium- and magnesium-salts first evolve sulphur, and then the greater part of the trisulphide, and leave a white unfused compound of magnesium- or calcium-sulphide, with a very small quantity of trisulphide; most of the heavy-metal-compounds evolve sulphur at first, and then all the sulphide of arsenic, so that nothing but the sulphur-base remains behind. The sulpharsenates, when heated in the air, give off orpiment and arsenious oxide, and leave a sulphate when the base contains an alkali-metal, and pure oxide if it contains a heavy metal. The aqueous solution of the sulpharsenate of an alkali-metal is decomposed by exposure to the air—the liquid becoming turbid, and depositing sulphur, pentasulphide of arsenic ($As^2S^3 + S^2$) and a brown salt of hyposulpharsenious acid, while alkaline arsenite and hyposulphite are formed, and the latter, by further oxidation, is converted into sulphate; the cooler and more concentrated the solution, the more slowly does the decomposition proceed. Acids, even carbonic acid, decompose the alkaline sulpharsenates, separating hydrosulphuric acid gas of a peculiar odour, and precipitating a mixture of arsenious sulphide and sulphur. Hydrated cupric oxide, introduced into the solution of an alkaline sulpharsenate, decomposes a portion of that compound, forming alkaline arsenate and sulphide of copper, a small portion of which dissolves in the liquid. A similar reaction is produced by other heavy metallic oxides which do not retain their oxygen with very great force. (Berzelius.)

Many sulpharsenates are soluble in water, namely, those of the alkali-metals, magnesium, yttrium, and glucinum. The solutions are either colourless or pale yellow. From the solutions of the dibasic salts alcohol precipitates a tribasic salt, and leaves monobasic salt in solution. When this solution is placed in a shallow dish, and evaporated at a gentle heat, there remains a lemon-yellow residue, from which water extracts a dibasic salt. (Berzelius.)

Sulpharsenate of Ammonium. $2(NH^4)^2S.As^2S^5 = (NH^4)^4As^2S^7$.—The solution of pentasulphide of arsenic in sulphide of ammonium, yields by evaporation, a viscid, reddish-yellow mass, which decomposes partially in drying, and still more when heated, first giving off a liquid containing disulphide of ammonium, and then yielding a sublimate of arsenious sulphide: $(NH^4)^4As^2S^7 = 4NH^4S + As^2S^3$.—The solution becomes brownish-yellow when boiled, and on cooling deposits a yellow powder composed of $(NH^4)^2S.12As^2S^5$. The aqueous solution of the dibasic salt is precipitated by alcohol, the *monammonic* or *acid* salt, NH^4AsS^3, then remaining in solution. If the solution be previously mixed with sulphide of ammonium and heated, alcohol throws down the *tri-ammonic* or *basic* salt $(NH^4)^3AsS^4$, in prismatic crystals.

Sulpharsenate of Antimony is a burnt-yellow, easily fusible precipitate.

Sulpharsenate of Barium.—The *tribarytic-salt*, $Ba^3As^2S^8$, is obtained by decomposing the tetrabarytic or neutral salt: 1, by a red heat; 2, by mixing its aqueous solution with sulphide of barium, the mixture evaporated in vacuo over sulphuric acid at the freezing point, yielding the basic salt in loose, transparent, non-crystalline scales; 3, by

with alcohol: it then falls down as a curdy precipitate, very soluble in
bly a hydrate:—The *dibasic salt*, $Ba^2As^2S^7 = 2Ba''S.As^2S^5$, is produced by
solution of neutral arsenate of barium with hydrosulphuric acid. The
up to a fissured lemon-yellow mass, which, if exposed to the air after all
been drawn off, absorbs water again, swelling up and falling to pieces
time. It dissolves in water in all proportions. With sulphate of potas-
ls a precipitate of sulphate of barium, and a solution of neutral sulph-
otassium.—The *monobarytic* or *acid* salt, $Ba''As^2S^6$, remains in solution
utral salt is precipitated by alcohol. It is decomposed by evaporation,
ellow deposit of the salt, $Ba''S.3As^2S^5$, while the neutral salt remains in

senate of Bismuth.—Both the basic and the neutral salts are dark-
itates, soluble in excess of the alkaline sulpharsenate.

senate of Cadmium is a light yellow powder.

senate of Calcium.—The *basic salt*, $Ca^3As^2S^8$, is obtained by mixing
of the neutral salt with sulphide of calcium, and either evaporating or
with alcohol; it is not crystallisable, and when precipitated by alcohol
a powder or a syrup, according to the quantity of water that it contains.
asily in water, but is insoluble in alcohol. The *neutral* salt, Ca^2AsS^7 =
is precisely analogous to the barium-salt. Its solution when evaporated
a syrup, which, if then left to evaporate further, dries up to a yellow
, becoming anhydrous at 60° C.: when exposed to the air, it absorbs
up, and detaches itself from the sides of the vessel. There appears to be
arsenate of calcium.

senates of Cerium.—The *ceric salt*, $2Ce^2S^3.As^2S^5$, is a yellowish white
not quite insoluble in water, and consequently not appearing in very
ons. The *cerous salts*, $Ce''S.As^2S^5$, and $3Ce''S.As^2S^5$, are obtained by
position as precipitates of a fine yellow colour, which become somewhat
dry.

senate of Cobalt, $Co^2As^2S^7 = 2Co''S.As^2S^5$, is a brown precipitate which
k when collected and dried, and dissolves with dark colour in excess of
e of sodium.

senate of Copper, $Cu^2As^2S^7 = 2Cu''S.As^2S^5$, is obtained as a dark brown
y treating solutions of copper-salts with neutral sulpharsenate of sodium,
sulphuretted hydrogen through an acid solution containing arsenic acid
xide: if the arsenic acid is in excess, the brown sulphur-salt is first
and then yellow sulphide of arsenic. From a precipitate of this kind,
mmonium dissolves not only the sulphide of arsenic, but likewise by its
a large portion of the sulphide of copper. Very dilute ammonia likewise
sulphide of arsenic: stronger ammonia acquires a brown tint by taking
he sulphide of copper. (Gm. v. 475.)

enate of Glucinum.—Pentasulphide of arsenic digested with hydrate
and water, is dissolved to a small amount and reprecipitated by acids.
lts are not precipitated by sulpharsenate of sodium.

enate of Gold.—The *tribasic salt*, $(\overset{\prime\prime\prime}{\breve{\mathrm{Au}}})AsS^4 = (\overset{\prime\prime\prime}{\breve{\mathrm{Au}}})^2S^3.As^2S^3$, is formed
ing a gold-solution with tribasic arsenate of sodium. It is a dark brown
soluble in pure water. Ferrous sulphate decolorises the solution, and

ow-brown substance not yet examined. The *dibasic salt*, $2(\overset{\prime\prime\prime}{\breve{\mathrm{Au}}})^2S^3.3As^2S^5$,
precipitation with neutral sulpharsenate of sodium, dissolves in pure
brown red colour.

senates of Iron.—The *ferric salt*, $2Fe^2S^3.3As^2S^5$, is a greyish-green
which dissolves with very dark colour in excess of the precipitant, is not
ying, but melts easily when heated, giving off sulphur, and being con-
erric sulpharsenite.—The *ferrous salt*, $2Fe''S.As^2S^5 = Fe^2As^2S^7$, is a dark
itate, which dissolves in excess of the alkaline sulpharsenate. It decom-
ying, assuming a rusty colour, and then consists of a mixture of the
lt with ferric oxide.

senate of Lead.—The salts $Pb^3As^2S^8$, and $Pb^2As^2S^7$, are obtained by
. The former is black-brown, the latter of a fine red colour; both turn
ing.

enate of Lithium.—The *basic salt*, Li^3AsS^4, is precipitated by alcohol
tion of the neutral salt in shining, colourless crystalline scales, soluble in
d separating therefrom on cooling in six-sided prisms, and by spontaneous

evaporation in four-sided tables with rhombic base. The *neutral* salt, $Li^4As^2S^7$, is non-crystalline lemon-yellow mass, which absorbs moisture from the air, and is perfectl soluble in water. The *acid* salt, $LiAsS^3$, is known only in alcoholic solution, bein decomposed by evaporation. The *hyperacid* salt, with 12 at. As^2S^5, is prepared lik the corresponding potassium-salt.

Sulpharsenate of Magnesium.—The *tribasic* salt, $Mg^3As^2O^8$ or $3Mg''S.As^2S^5$, i obtained by adding sulphydrate of magnesium to a solution of the neutral salt as lon as sulphuretted hydrogen continues to escape, and afterwards evaporating the solutio or if it be not too dilute, cooling it quickly down. It forms colourless radiatin crystals, which become moist on exposure to the air. Alcohol decomposes them extracting the neutral salt and leaving a compound of 1 at. As^2S^5 with more tha 3 at. Mg^2S, which is nearly insoluble in water. The same compound remains as white unfused mass, when the neutral salt is heated to redness in a retort. Pota added to the aqueous solution of the tribasic salt precipitates magnesia, and forms solution of tribasic sulpharsenate of potassium.—The *neutral salt*, $2Mg''S.As^2S^5$, is non-crystalline, lemon-yellow mass, which does not absorb water from the air, di solves in water to any amount, and is precipitated from the solution by alcohol.

Sulpharsenate of Magnesium and Ammonium, $(NH^4)Mg''AsS^4$ (?)—Precipitated adding alcohol to an aqueous solution of the mixed sulpharsenates of magnesium an ammonium, in delicate white needles, which, when exposed to the air, give off sul phuretted hydrogen and turn yellow. It dissolves easily in water.

Sulpharsenate of Manganese.—The *neutral salt*, $2Mn''S.As^2S^5$, is obtained b digesting recently precipitated sulphide of manganese with water, trisulphide arsenic and sulphur, partly dissolving in the water and partly remaining at the botto in the form of a lemon-yellow powder, which however dissolves in a larger quantit of water. The solution when evaporated, yields sulphur, and afterwards deposits lemon-yellow mass, no longer completely soluble in water. The neutral salt is like wise obtained, but mixed with arsenate of manganese, when carbonate of mangane is boiled with water and trisulphide of arsenic and sulphur. Manganous salts ar not precipitated by sulpharsenate of sodium. A *sexbasic salt*, $6Mn''S.As^2S^5$, is produc by digesting the yellow powder of the neutral salt in strong ammonia. It is a brick red powder, somewhat soluble in water, and, when ignited at one point, continues t burn.

Sulpharsenates of Mercury.—The *mercuric salt*, $2Hg''S.As^2S^5$, is precipitate from mercuric chloride both by basic and by neutral sulpharsenate of sodium, as dark yellow substance, which retains its colour after drying. It sublimes undecom posed, and yields a powder of the colour of cinnabar. The *mercurous salt*, $2Hg^2S.As^2S^5$ or $(Hg^2)^2As^2S^7$, is precipitated black from solutions free from mercuric oxide; i the latter is present, the precipitate is brownish-yellow, and becomes darker i drying. When distilled, it decrepitates violently and gives off mercury, and at higher temperature yields a sublimate of the mercuric salt just described.

Molybdic Acid is is not precipitated by sulpharsenate of sodium.

Sulpharsenate of Nickel.—Nickel-salts, if not too dilute, immediately yield black precipitate, with neutral or basic sulpharsenate of sodium. Very dilute solution first assume a yellow-brown colour, then yield a precipitate.

Sulpharsenate of Platinum.—The neutral and basic sodium-salts do no precipitate platinum-solutions, but merely colour them dark-brown. Ferrous sulphat added to the brown liquid, throws down a black-brown substance, while the solutio becomes colourless.

Sulpharsenate of Potassium.—The *tribasic salt*, $3K^2S.As^2S^5$, or K^3AsS^4, i deposited as an oily concentrated solution, on mixing the aqueous solution of th neutral salt with alcohol. When dried at a gentle heat, it leaves a fibrous deliquescent mass.

The *neutral* or *dibasic* salt, $2K^2S.As^2S^5$, or $K^4As^2S^7$, is produced by saturating a aqueous solution of dipotassic arsenate with hydrosulphuric acid and evaporating i vacuo. The residue is a viscid, yellowish, somewhat crystalline mass, which does not dry up completely, but on exposure to the air first liquefies and then solidifies in crystalline mass of rhombic tablets.

The *monobasic* or *acid* salt, $K^2S.As^2S^5$, or $KAsS^3$, remains dissolved when the aqueou solution of the neutral salt is precipitated with alcohol. The solution is decomposed by evaporation, and deposits crystals of persulphide of arsenic (see p. 386).— 2 Aqueous sulphide of potassium dissolves at ordinary temperatures, more than ½ at but less than 1 at. of pentasulphide of arsenic. The solution, when evaporated in the air, first becomes covered with a film of sulphur, then deposits a red crust, and by this loss of sulphide of arsenic, is converted into the dibasic salt, which dries up first to a stiff syrup and then to a lemon-yellow mass.

cid salt, $K^2S.12As^2S^5$, is precipitated when the solution of the neutral salt
ed by carbonic acid; similarly on passing hydrosulphuric acid gas through
c arsenate.—It is a yellow powder, containing 2·9 sulphide of potassium
ntasulphide of arsenic. (Berzelius.)

rsenate of Potassium. $(K^2O.2H^2O)As^2S^2O^3 = (K^2H^4)As^2S^2O^6$. — Produced
uretted hydrogen is rapidly passed through a cold saturated solution of dipo-
ate (p. 383). The liquid first turns yellow, then deposits a small quantity of
of arsenic mixed with sulphur, and ultimately a colourless crystalline salt.
tain quantity of this salt has been formed, caustic potash is to be added to
and the stream of sulphuretted hydrogen continued: by this means, an
quantity is obtained. The greater part of the sulphide of arsenic must
sed away with the mother-liquor, and the salt washed with very small
f water, pressed, and dried in vacuo. It crystallises in small white
risms, sometimes 1 or 2 centimetres long, slightly soluble in water. The
ermanent in the air, and gives up all its water at 170° C., without melting.
the spirit-lamp, giving off, first arsenic sulphide and then metallic arsenic.
s solution decomposes rapidly at a boiling heat, giving off hydrosulphuric
positing sulphur. If hydrochloric acid be then added, a precipitate of sul-
senic is obtained. From the salt itself, hydrochloric acid precipitates
t sulphur, and the precipitation is complete; the filtrate then contains
id. Lead-salts added to the solution give a white precipitate, which soon
The acid of this salt, $H^6As^2S^2O^6$ (arsenic acid, having part of its oxygen
sulphur), cannot be obtained in the free state. If the lead-salt,
after its formation, be collected on a filter and mixed with a quantity
lphuric acid less than sufficient to decompose it completely, a strongly acid
tained, which gives no precipitate with barium-salts; but it quickly decom-
eposits sulphide of arsenic. (Bouquet and Cloez, Ann. Ch. Phys. [3]

rsenate of Silver.—Both the *neutral* and *basic* salts are precipitated from
ons, with brown colour, turning black in drying; the precipitates are very
ing down. When they are heated in the air, the sulphide of arsenic burns
ulphide of silver remains; but if heated to redness in close vessels, they
t giving off sulphur or sulphide of arsenic, and on cooling solidify in the
rey, somewhat ductile cake, exhibiting metallic lustre.

rsenate of Sodium. *a. Tribasic salt.* $3Na^2S.AsS^5 + 15H^2O = 2Na^3AsS^4 +$
btained: 1. By precipitating a solution of the dibasic salt with alcohol.—
ng a mixture of the dibasic salt *b* and sulphydrate of sodium to evaporate.
gesting the alcoholic solution of pentasulphide of sodium with orpiment,
liquid off, washing the residue with alcohol, then dissolving out the tri-
ith water, and leaving the solution to crystallise.—4. By dissolving penta-
arsenic in aqueous soda-solution, and leaving the liquid to crystallise.
s obtained by either of these methods are washed on a filter with alcohol, then
dried (Berzelius).—5. By boiling 1 pt. of sulphur, 1¼ pt. of orpiment,
of crystallised carbonate of soda with water, and purifying the crystals ob-
the filtrate by recrystallisation (Rammelsberg, Pogg. Ann. liv. 238).
(1) the salt is obtained in snow-white crystals; by (4) in ill-defined rhom-
a. It crystallises by slow cooling from a hot aqueous solution, in irregular
risms, with two of their lateral edges more acute than the rest; by spon-
poration or very slow cooling, in transparent rhombic prisms with dihedral
sting on the acute lateral edges; and by still slower cooling, till the tem-
lls below 0° C., in white, opaque, rhombic octahedrons. The opaque
milk-white; the transparent crystals are yellowish, and have somewhat
d lustre. (Berzelius.)

when dry is permanent in the air; even in vacuo over oil of vitriol, it
re up its water till gently heated; it then becomes milk-white; when more
ated, it gives off a small quantity of hydrosulphuric acid, and turns yellow.
retort, in fuses it its water of crystallisation, forming a very pale yellow
gives off water, and is converted into a white salt, which, when more
ated, decrepitates slightly, evolves the remaining water and a small quan-
rosulphuric acid, and fuses to a dark red liquid; on cooling, this liquid
d forms the yellow anhydrous compound, Na^3AsS^4 (Berzelius). It is
completely by boiling with sulphate of copper, yielding a precipitate of
copper, while soda, sulphuric acid, and arsenic acid remain in solution:

$$a^3AsS^4 + 4Cu^2SO^4 + 4H^2O = 4Cu^2S + Na^3AsO^4 + 4H^2SO^4.$$

decomposition takes place with acetate of lead; but the precipitated sul-
d [if the acetate is in excess], is mixed with arsenate of lead, because that

salt is insoluble in acetic acid (Rammelsberg). The salt dissolves easily and abundantly in water. (Berzelius.)

b. Dibasic or *Neutral salt.* $2Na^2S.As^2S^5 = Na^4As^2S^7$.—The aqueous solution of disodic arsenate saturated with hydrosulphuric acid gas, and then left to evaporate spontaneously, yields a viscid liquid, and afterwards, if gently heated, a dry lemon-yello mass. This substance melts at a moderate heat, forming a very pale yellow liqui (losing water at the same time if warmed in an open vessel), and on cooling solidifie in a yellow mass, which softens when exposed to the air. (Berzelius.)

c. Monobasic salt. $Na^2S.As^2S^5 = NaAsS^3$.—When the tribasic salt is prepared wit alcohol according to method (1), the supernatant alcoholic solution contains th mono-basic salt. On distilling off the alcohol, the liquid often deposits persulphid of arsenic in beautiful crystals.

d. Hyper-acid salt, $Na^2S.12As^2S^5$.—Yellow powder, obtained like the potassiu compound. (Berzelius.)

Sulpharsenate of Sodium and Ammonium, $(NH^4)^3AsS^4.Na^3AsS^4$, is obtained b mixing the solutions of the two basic salts with alcohol, and cooling slowly, whereupon it collects on the sides of the vessel in small four-sided tables; or more easily b dissolving sal-ammoniac in an exactly proportional quantity of the basic sodium-sal and leaving the solution to evaporate; it then separates in yellowish six-sided prism permanent in the air, and much more soluble in water than the sodium-salt. Whe distilled, it gives off sulphide of ammonium with a little water, leaving sulpharsenit of sodium.

The neutral sulpharsenates of sodium and ammonium dry up to a yellow mass whe mixed.

Sulpharsenate of Sodium and Potassium.—Very regular four-sided tables, havin a faint yellowish colour.

Sulpharsenate of Strontium.—The *neutral* salt is obtained in the same manne as the barium-compound. On mixing the solution with alcohol, the *basic* salt is precipitated, sometimes as a syrup, sometimes as a white powder, according as it is more o less purified from the neutral salt.

Sulpharsenates of Tin.—Both the neutral and basic sodium-salts form wit *stannous* chloride, a dark chestnut-brown precipitate; with *stannic* chloride, pal yellow gummy precipitates, becoming orange-yellow when dry.

Uranic Sulpharsenate.—The *neutral* salt, $2U^2S^3.As^2S^5$ or $(U^2S^2)^2As^2S^7$, is dingy yellow precipitate; the basic salt has a somewhat darker colour. Both dissolve with dark brown colour in excess of the precipitant.

Vanadic salts give no precipitate with sulpharsenate of sodium; but the blu solution is decolorised.

Sulpharsenate of Yttrium.—Resembles the glucinum-salt.

Sulpharsenate of Zinc.—The *neutral* salt is a light yellow precipitate, the *basi* salt till lighter; both are orange-yellow when dry.

Sulpharsenate of Zirconium.—Solutions of zirconium-salts are precipitated, though not immediately, both by basic and by neutral sulpharsenate of sodium; the precipitate is lemon-yellow while moist, orange-yellow after drying. Acids do not extract zirconia from it.

ARSENICAL COBALT, COPPER, IRON, &c. See the several metals.

ARSENICAL PYRITES. See IRON, ARSENIDES OF.

ARSENICAL PYROPHORUS. Arsenite of barium ignited with gum-tragacanth, is said by Osann to yield a greyish-yellow pyrophoric mixture.

ARSENIC-RADICLES (ORGANIC). Arsenic unites with the alcohol-radicles, forming compounds analogous to those of antimony, and containing 1 at. arsenic, combined with 1, 2, 3, or 4 at. of the organic radicle. The following is a list of the compounds of this class at present known. Those to which no formulæ are assigned, have been but imperfectly studied.

Arsenides of Allyl.

Arsenides of Amyl.

Arsenides of Ethyl:

Arsenethyl	$As(C^2H^5)$
Arsendiethyl, or Ethyl-cacodyl . . .	$As(C^2H^5)^2$
Arsentriethyl, or Triethylarsine . . .	$As(C^2H^5)^3$
Arsenethylium, or Tetrethylarsonium . .	$As(C^2H^5)^4$

en-bromethyl-triethylium	$As(C^2H^4Br)(C^2H^5)^3$
envinyl-triethylium	$As(C^2H^3)(C^2H^5)^3$
ylene-hexethyl-diarsonium	$As^2(C^2H^4)''(C^2H^5)^6$
ylene-triethylarsammonium	$AsNH^3(C^2H^4)''(C^2H^5)^3$
arsenethylium	$As(C^2H^5)^3Au$
tarsenethylium	$As(C^2H^5)^3Pt$

s of Methyl:

enmethyl	$As(CH^3)$
endimethyl, or Cacodyl	$As(CH^3)^2$
entrimethyl, or Trimethylarsine . . .	$As(CH^3)^3$
enmethylium, or Tetramethylarsonium . .	$As(CH^3)^4$
entrimethyl-ethylium	$As(CH^3)^3(C^2H^5)$
endimethyl-diethylium	$As(CH^3)^2(C^2H^5)^2$
enmethyl-triethylium	$As(CH^3)(C^2H^5)^3$
endimethyl-diamylium	$As(CH^3)^2(C^5H^{11})^2$

of Tetryl (or Butyl).

of Trityl (or Propyl).

pounds are produced, like the antimonides of the alcohol-radicles, by dis-
odides of these radicles with arsenide of potassium or sodium. Arsen-
cacodyl, is likewise formed by distilling a mixture of arsenious oxide and
acetate, and was obtained in this manner by Cadet, so long ago as 1760.
and di-tetryl compounds appear to be produced in a similar manner, by
enious oxide with an alkaline valerate or butyrate. The compounds con-
3 at. of alcohol-radicle, *e. g.* cacodyl and arsentriethyl, have been obtained
ate; the rest only in combination.

unds containing 1 at. alcohol-radicle, such as $As(CH^3)$, are di-atomic and
uniting with 2 and 4 at. Cl, I, &c.; those with 2 at. alcohol-radicle,
example, are mono- and tri-atomic; those with 3 at. alcohol-radicle,
r example, are di-atomic; and those which contain 4 at. alcohol-radicle,
)^4, are monatomic and triatomic. (See ORGANO-METALLIC BODIES.)

s of Allyl. When iodide of allyl is heated with arsenide of potas-
ber of liquid products are formed, having an extremely offensive odour,
adually in boiling point, so that their separation cannot well be effected,
ame time, a solid crystalline mass is formed, which appears to be the
rsenallylium or tetrallylarsonium, $As(C^3H^5)^4I$. (Cahours and
Phil. Trans. 1857, p. 335.)

s of Amyl. Iodide of amyl distilled with arsenide of potassium,
unds analogous to the arsenides of ethyl and methyl. (Cahours and

Arsenides of Ethyl.*

ese compounds, viz. *arsendiethyl*, $As(C^2H^5)$, *arsentriethyl*, $As(C^2H^5)^3$, and
, $As(C^2H^5)^4$, are obtained by a process similar to that already described
ration of stibtriethyl (p. 341), viz. by subjecting arsenide of sodium mixed
sand, to the action of iodide of ethyl in an atmosphere of dry carbonic
he action takes place without external heating, and when it is finished, the
enides of ethyl may be separated one from the other either by fractional
or by treatment with ether. *Arsenethyl*, AsC^2H^5, is obtained by the
n of arsendiethyl.

HYL, or ARSENMONETHYL, $As(C^2H^5) = AsE$.—This radicle is not
free state; but the di-iodide is obtained (together with iodide of ethyl),
of 2 at. iodine on 1 at. iodide of arsendiethyl, or of 3 at. iodine on 1 at.
:

$$AsE^2I + I^2 = EI + AsEI^2$$
$$AsE^3 + I^3 = EI + AsEI^2.$$

ide distilled with 2 at. *iodine*, yields tri-iodide of arsenic ($AsEI^2 + I^2 =$
Treated with excess of *oxide of silver* and *water*, it is converted into
thylic acid, $As(C^2H^5)H^2O^3$. (Cahours, Compt. rend. l. 1022; Rép.
i. 256.)

THYL, or ETHYL-CACODYL, $As(C^2H^5)^2$, is best obtained by treating
odium with excess of iodide of ethyl, in the manner just mentioned,

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Ann. Ch. Pharm. lxxxix. 301; xcii. 365; Gm. ix. 70; Gerh. ii. 949.—Cahours and
rend. xxxvi. 1001; xxxix. 541; Jahresber. f. Chem. 1853, 487; 1854, 530.—Cahours,
lix. 87; Jahresber. 1859, 430; further, Compt. rend. l. 1022; Rép. Chim. pure, ii. 255.

digesting the crude distillate with ether, mixing the ethereal extract with absolut alcohol, expelling the ether by evaporation, and mixing the alcoholic solution with water, which precipitates arsendiethyl, and retains in solution the iodide of arsenethylium, formed by the union of arsentriethyl with the excess of iodide of ethyl.

Arsendiethyl is an oily liquid, having a faint yellowish colour, strong refractin power, and a very disagreeable, pungent, alliaceous odour. It sinks in water withou mixing. Boils between 185° and 190° C. It absorbs oxygen rapidly from the ai giving off vapours of arsenious oxide, and if it has been separated by fractional distillation, it takes fire when a drop of it is let fall on wood or paper; but if it has bee precipitated by water from the alcoholic solution, it does not take fire till heated t 180° C. It is rapidly oxidised by strong nitric acid, with evolution of light and heat, less completely by dilute nitric acid, which also forms with it a red substance analogou to Bunsen's *erythrarsin*. Arsendiethyl reduces the noble metals, silver, mercury, &c from their solutions, and is at the same time converted into *arsendiethylic aci* $As(C^2H^5)^2HO^2$.

Arsendiethyl also unites directly with *chlorine*, *bromine*, *iodine*, and *sulphur*. Thes compounds are liquids having a peculiarly repulsive and persistent odour, and attackin the eyes strongly; continued exposure to it produces headache and other unpleasan symptoms. The iodide, $As(C^2H^5)^2I$, is prepared by saturating an ethereal solution o arsendiethyl with an ethereal solution of iodine, and evaporating the ether. It is yellow oil, insoluble in water, but soluble in alcohol and ether. The alcoholic solutio mixed with nitrate or sulphate of silver, yields a precipitate of iodide of silver, and solution of nitrate or sulphate of arsendiethyl.

On gradually adding a dilute alcoholic solution of *mercuric chloride* to an alcoholi solution of arsendiethyl, a white precipitate is formed, which however disappear on boiling, and the solution yields on cooling a crystalline powder, consisting o $2Hg^2O.As(C^2H^5)^2Cl^2$. This salt is inodorous, sparingly soluble in cold water and i alcohol, more soluble in boiling water: it is decomposed by strong nitric acid. Tw other crystalline compounds are formed at the same time, in small quantity.

Arsendiethylic Acid. $As(C^2H^5)^2HO^2$.—When arsendiethyl is triturated with red oxide of mercury under water, mercury separates out, and a solution of arsendiethylate of mercury is formed; and by precipitating the mercuric oxide with barytawater, removing the excess of baryta by carbonic acid, decomposing the filtered solutio of arsendiethylate of barium with sulphuric acid, and evaporating, arsendiethylic aci is obtained in crystals. This acid is also produced by the direct oxidation of arsendiethyl, as when that substance is left for some time in a loosely stoppered bottle; als when its alcoholic solution is exposed to the air, or more quickly when that solutio is shaken up with oxygen gas. The crystals contain $As(C^2H^5)^2HO^2$. They ar inodorous, have a slightly acid, afterwards bitter taste, deliquesce in the air and dissolve readily in water and alcohol, sparingly in ether. They melt a 190° C., forming an oily liquid, which solidifies in a crystalline mass on cooling; bu at higher temperatures, they are decomposed, with evolution of arsenious oxide an stinking arsenical products. The acid is not attacked by nitric acid, aqua-regia, or b the milder reducing agents, such as sulphurous acid, and ferrous sulphate; but phosphorous acid reduces it, forming a pungent oily liquid, probably the oxide of arsendiethyl. The aqueous solution of the acid readily decomposes carbonates, and precipitate *ferric*, *mercurous*, and *cupric* salts; also acetate of *lead*. The *mercuric* salt is a deliquescent crystalline mass. The *barium*-salt, obtained by saturating the aqueous aci with baryta-water and evaporating, contains $Ba''H^2O^2.3As(C^2H^5)^2HO^2 + \frac{1}{2}H^2O$; th water of crystallisation is not completely given off at 120° C.

ARSENTRIETHYL, or TRIETHYLARSINE. $As(C^2H^5)^3$.—This is the chief product of the action of iodide of ethyl on arsenide of sodium, and is easily separated from th other products by fractional distillation in an atmosphere of carbonic anhydride: i passes over between 140° and 180° C. It is also produced by the action of trichlorid of arsenic on zinc-ethyl (Hofmann and Cahours, Compt. rend. xli. 831). It is colourless, mobile, strongly refracting liquid, having a disagreeable odour, like that o arsenetted hydrogen. Specific gravity 1·151 at 16·7° C. Under a pressure of 736 mm. it begins to boil at 140° C., but the boiling point quickly rises to 180°, a small quantity of arsenic separating at the same time. Its vapour-density is, by experiment, 5·2783; by calculation (2 vol.) 5·6156.

Arsentriethyl fumes and becomes heated in contact with the air, but seldom takes fire unless it is heated; the products of the oxidation are arsenious anhydride, carbonic anhydride and water. The oxidation takes place slowly, even under water in a closed vessel. Strong *nitric acid* oxidises it rapidly, with vivid combustion and explosion, but nitric acid of specific gravity 1·42, dissolves it slowly, giving off nitric oxide, and producing nitrate of arsentriethyl; but no red compound is formed. This character serves to

arsentriethyl from arsendiethyl: a further distinction is afforded by the
entriethyl does not reduce the noble metals from their solutions.

thyl is a diacid radicle, 1 at. of it uniting with 2 at. of a monatomic acid
$As(C^2H^5)^3.I^2$, and with one at. of a diatomic acid radicle, *e.g.* $As(C^2H^5)^3.S$.

of Arsentriethyl, $As(C^2H^5)^3Br^2$, is obtained by mixing the alcoholic solu-
ine and arsentriethyl, the former in slight excess, and evaporating at 100° C.
wish, deliquescent, crystalline mass, the odour of which excites sneezing.
d it melts, and burns with a white flame. It is decomposed by chlorine,
d, and by strong sulphuric acid.

f Arsentriethyl, $As(C^2H^5)^3I^2$, is obtained by mixing the ethereal solutions
uents: it is then deposited in yellow flakes which rapidly turn brown and
xposure to the air. It dissolves readily in water and alcohol, sparingly in

ride appears to be formed in small quantity by the action of hydrochloric
oxide or sulphide.

f Arsentriethyl, $As(C^2H^5)^3O$, is produced when an ethereal solution of
l is left to evaporate in the air; but it may be obtained in a state of greater
hausting the mass produced by the action of iodide of ethyl on arsenide of
t with ether, and then with alcohol, evaporating the alcoholic solution, and
e residue. It is an oily liquid, heavier than water and not miscible with
ole in alcohol, and precipitated from the alcoholic solution by water. It
dilute nitric acid, but not in sulphuric or hydrochloric acid. When left
eks in a loosely stoppered bottle, it is gradually converted into an inodorous
ubstance [probably arsentriethylic acid].

e of Arsentriethyl, $As(C^2H^5)^3S$, is obtained by boiling an ethereal solution
thyl with flowers of sulphur. It forms beautiful prismatic crystals, which
rified by recrystallisation from boiling water or alcohol, or better by
warm ether, and gradual evaporation. It has a bitter taste, but is quite
hen pure. It melts at 100° C., and decomposes at a higher temperature,
pontaneously inflammable vapours. It is rapidly oxidised by strong *nitric*
te *hydrochloric acid* decomposes it partially, giving off small quantities of
ric acid and *chloride of arsentriethyl*, recognisable by its peculiarly pungent
is not decomposed by boiling with *caustic potash*. Its aqueous solution
metallic solutions like an alkaline sulphide.

THYLIUM or TETRETHYLARSONIUM, $As(C^2H^5)^4$, is not known in the free
obtained as an iodide by the action of iodide of ethyl on arsentriethyl; also,
Cahours and Riche, by the action of metallic arsenic on iodide of ethyl.
nds are analogous to those of tetrethylium, and contain 1 at. arsenethylium
f a monobasic acid radicle, or 2 at. arsenethylium with 1 at. of a dibasic
. The *hydrate*, obtained by the action of oxide of silver on the iodide,
ase resembling hydrate of potassium, and dissolves readily in acids, forming
crystallise readily, are permanent in the air, have a bitter taste, and do
to be poisonous. In this respect, they differ remarkably from the com-
rsendiethyl and arsentriethyl.

e of Arsenethylium, $As(C^2H^5)^4Br$, is a white, deliquescent, saline mass,
olves easily in water and alcohol, and exhibits with acids and metallic
me reactions as bromide of potassium.

le of Arsenethylium forms crystals containing $As(C^2H^5)^4Cl.4H^2O$,
olve readily in water and alcohol, but are insoluble in ether. The aqueous
mediately precipitates chloride of silver from the nitrate and forms an in-
ble salt with *mercuric chloride*. With *tetrachloride of platinum* it forms the
$As(C^2H^5)^4Cl.PtCl^4$, which dissolves very sparingly in cold, somewhat more
oiling water.

of Arsenethylium, $As(C^2H^5)^4I$, forms large colourless crystals, easily
water and alcohol, but insoluble in ether. When heated, they fall to
e off spontaneously inflammable vapours, and yield a sublimate of arsenic.
composed by nitric and by sulphuric acid. A compound of *iodide of arsen-*
d *iodide of arsenic* is obtained by heating iodide of ethyl to 100° C.
c arsenic:

$$4C^2H^5I + As^2 = As(C^2H^5)^4I.AsI^3.$$

und forms splendid red tables, which are decomposed by distillation, yield-
f arsentriethyl and iodide of arsendiethyl (Cahours and Riche, Compt.
546). It is also decomposed by hot potash-solution, yielding iodide of
m, iodide of potassium, and arsenite of potassium. Iodide of arsenethylium

heated with *iodide of zinc*, yields the compound $2As(C^2H^5)^4I.Zn''I^2$; simila
iodide of cadmium.

Arsenethylium likewise forms a *tri-iodide*, $As(C^2H^5)^4I^3$, analogous to the t
of tetrethylium discovered by Weltzien. (Cahours, Compt. rend. l. 1022; Ré
pure, ii. 255.)

The *sulphate*, $[As(C^2H^5)^4H]SO^4$, is formed by precipitating a solution of t
with an acid solution of sulphate of silver. Granular crystals, easily soluble
and alcohol, sparingly in ether, and decomposed by heat, with evolution of acid

ARSEN-BROMETHYL-TRIETHYLIUM, or **BROMETHYL-TRIETHYLAR**
$As(C^2H^4Br)(C^2H^5)^3$.—The *bromide* of this radicle is obtained by heating a m
triethylarsine with a very large excess of dibromide of ethylene, in sealed t
temperature not above 50° C., extracting the product with water, evaporating ar
tallising from boiling alcohol. It forms beautiful crystals, extremely soluble
the form of which exactly resembles that of the corresponding phosphonium-c
(see PHOSPHORUS-RADICLES, ORGANIC). It contains the elements of 1 at. d
of ethylene and 1 at. triethylarsine:

$$C^2H^4Br^2 + As(C^2H^5)^3 = [As(C^2H^4Br)(C^2H^5)^3]Br.$$

Nitrate of silver added in excess to the solution of the bromide, precipitates
the bromine; the other half is precipitated on treating the filtrate with
(see AMMONIUM-BASES, p. 196). The platinum-salt of this radicle forms
yellow needles, sparingly soluble even in boiling water. (A. W. Hofmann, P
Soc. xi. 62.)

ARSENVINYL-TRIETHYLIUM, or **VINYL-TRIETHYLARSONIUM.**
$(C^2H^5)^3$.—The hydrated oxide of this radicle is obtained by treating bromide
methyl-triethylarsonium with excess of oxide of silver:

$$[As(C^2H^4Br)(C^2H^5)^3]Br + Ag^2O = \left.\begin{matrix}As(C^2H^3)(C^2H^5)^3\\ H\end{matrix}\right\}O + 2AgBr.$$

A strongly alkaline solution is obtained which, when treated with hydrochl
and precipitated by tetrachloride of platinum, yields beautiful, rather solu
hedrons, containing $2[As(C^2H^3)(C^2H^5)^3]Cl.PtCl^4$. (Hofmann, *loc. cit.*)

ETHYLENE-HEXETHYLDIARSONIUM. $As^2(C^2H^4)''(C^2H^5)^6$.—Obtained as
mide or dichloride, by digesting the bromide or chloride of bromethyl-triethyla
with triethylarsine at 150° C. for two hours. The dibromide $[As^2(C^2H^4)''(C^2H$
treated with oxide of silver, yields the hydrate $\left.\begin{matrix}[As^2(C^2H^4)''(C^2H^5)^6]''\\ H^2\end{matrix}\right\}O^2$, wh
powerful alkali, and forms with acids a series of beautiful salts:

The *platinum-salt*. $[As(C^2H^4)''(C^2H^5)^6]''Cl^2.PtCl^4$, is a pale yellow crystal
cipitate, soluble in water and in boiling hydrochloric acid, from which it cry
on cooling.

The *gold-salt*, $[As^2(C^2H^4)''(C^2H^5)^6Cl^2.2AuCl^3$, crystallises from hydrochloric
gold-coloured plates. (Hofmann, *loc. cit.*)

ETHYLENE-TRIETHYLARSAMMONIUM $\left[(C^2H^4)''\begin{matrix}(C^2H^5)^3As\\ H^3N\end{matrix}\right]''$. The *dibr*
this radicle is obtained by heating the bromide of bromethyl-triethylarsoniu
ammonia to 100° C. for two hours. Treated with oxide of silver, it yields the
base $\left.\begin{matrix}[(C^2H^4)''(C^2H^5)^3H^3AsN]''\\ H^2\end{matrix}\right\}O^2$. The *platinum-salt* $\left[(C^2H^4)''\begin{matrix}(C^2H^5)^3As\\ H^3N\end{matrix}\right]''$ C
crystallises from hydrochloric acid in needles, sparingly soluble in boiling wate
gold-salt crystallises from hydrochloric acid in golden-yellow plates. (Ho
loc. cit.)

The reactions by which the last four bases are obtained are precisely si
those which yield the corresponding compounds of the phosphorus series, and
more fully considered in the article PHOSPHORUS-RADICLES (ORGANIC), in wh
the *phospharsoniums*, containing both phosphorus and arsenic, will be describe

AURARSENETHYLIUM, $As(C^2H^5)^3Au$, and **PLATARSENETHYLIUM**, $As^2(C$
—The chlorides of these compounds are obtained in fine crystals by tre
alcoholic solution of arsentriethyl with trichloride of gold and dichloride of
respectively. (Hofmann, Ann. Ch. Pharm. ciii. 357.)

Arsenides of Methyl.

Cadet discovered, in 1760, that by distilling acetate of potassium with a
oxide, a fetid brown-red liquid is obtained, which takes fire on exposure to
But the nature of this liquid was not understood till Bunsen undertook its exam
and showed that it contained a metalloïdal radicle, AsC^2H^6, to which he g
the name Cacodyl (from κακος, bad) on account of its extremely poisonous

reover, isolated this radicle, and prepared a great number of its compounds, , in its chemical relations, it is precisely analogous to a simple metal. second instance of the isolation of a compound radicle, the separation of Gay-Lussac having been the first. It has since been shown by Cahours and pt. rend. xxxix. 341), that cacodyl or arsendimethyl, $As(CH^3)^2$ may y the action of iodide of methyl on arsenide of sodium, other arsenides of $As(CH^3)^3$ and $As(CH^3)^4$ being formed at the same time. Lastly, Baeyer, several compounds of arsenmonomethyl, $AsCH^3$.

THYL, OR ARSENMONOMETHYL, $AsCH^3 = AsMe$.—(Baeyer, Ann. vii. 279.) The *dichloride* of this radicle (which is not known in the sepa- s produced either by the decomposition of trichloride of arsendimethyl heat:

$$\underset{\text{Trichloride of cacodyl.}}{AsMe^2Cl^3} = \underset{\text{Dichloride arsenmethyl.}}{AsMeCl^2} + \underset{\text{Chloride of methyl.}}{MeCl}$$

ion of hydrochloric acid on cacodylic acid:

$$AsMe^2O^2H + 3HCl = AsMeCl^2 + MeCl + 2H^2O.$$

m of dry hydrochloric acid gas is passed over cacodylic acid, basic per- acodyl (p. 408) is first formed; but by the continued action of the gas, d is also decomposed, with separation of water, which passes over in the ether with the dichloride.

of arsenmethyl is a colourless, heavy, mobile liquid, having a strong wer. It boils at 133° C., which is nearly the boiling point of tri- senic. It does not fume in the air, and is not decomposed by water, but er freely in that liquid. It forms a white precipitate with sulphuretted he vapour of this compound exerts a most violent action on the mucous on smelling it, the eyes, nose, and the whole face swell up, and a peculiar ain is felt, extending down to the throat.

oride of Arsenmethyl, $AsMeCl^4$.—When chlorine is passed over a ichloride of arsenmethyl and sulphide of carbon cooled to − 10° C., large btained, which immediately decompose at temperatures near the freezing er, yielding chloride of methyl and trichloride of arsenic: hence the st of tetrachloride of arsenmethyl:

$$AsCH^3Cl^4 = AsCl^3 + CH^3Cl.$$

omide of Arsenmethyl, AsMeClBr, appears to be produced by the decomposition of chlorodibromide of cacodyl, bromide of methyl being he same time:

$$AsMe^2ClBr^2 = AsMeClBr + MeBr;$$

l product of the decomposition is too unstable to admit of an examination ies.

Arsenmethyl, $AsCH^3I^2$, is obtained by the action of hydriodic acid on solution of the oxide (see below). The liquid yields by spontaneous shining yellow needles of the iodide an inch long. They are not altered th the air, but appear to decompose slowly by keeping (Baeyer). The nd is produced by the action of 2 at. iodine on iodide of cacodyl, or of on free cacodyl, iodide of methyl being set free at the same time. ompt. rend. l. 1022):

$$AsMe^2I + I^2 = MeI + AsMeI^2$$
$$AsMe^2 + I^3 = MeI + AsMeI^2$$

° C., and often remains liquid for a long time after cooling. It is colourless without decomposition above 200° C. It is but slightly soluble in water, readily in alcohol, ether, and sulphide of carbon; less readily, however, free hydriodic acid. Hydrochloric acid converts it into chloride, and ic acid into sulphide of arsenmethyl. (Baeyer.) Distilled with 2 at. ds iodide of methyl, and triiodide of arsenic, AsI^3. (Cahours.)

Arsenmethyl, $As(CH^3)O$, is produced by the action of potash on the

$$AsMeCl^2 + 2KHO = AsMeO + 2KCl + H^2O;$$

ing the product with excess of potash, complete decomposition takes place cacodyl is obtained, instead of oxide of arsenmethyl (see below).

A better result is obtained by saturating the dichloride with carbonate of
then adding an excess of the latter, extracting with absolute alcohol, distill
alcohol in a stream of carbonic acid, digesting the residue in sulphide
which leaves chloride of potassium and other impurities undissolved, and l
clear solution to evaporate. Oxide of arsenmethyl is then obtained in la
crystals (not regular, however), which soon become dull, and assume the
white porcelain; sometimes, however, crystals are obtained which retain t
parency, but they are then very imperfectly developed. The oxide is
permanent in the air, and has a strong odour like that of asafœtida. I
slowly but abundantly in cold water, readily in hot water, also in alcohol,
sulphide of carbon. It melts at 95° C., and remains liquid for a conside
after cooling. It is decomposed by distillation, and the evolved vapours ex
mixed with air. A portion volatilises, however, with the vapour of water
By distillation with hydrate of potassium, it is resolved into arsenious oxide
of cacodyl:

$$4As(CH^3)O = As^2O^3 + As^2(CH^3)^4O.$$

The oxide appears to possess rather basic than acid properties, as it doe
with baryta, but dissolves readily in acids; its aqueous solution is neutr
table colours. *Hydrochloric acid* added to the concentrated aqueous solut
down the chloride of arsenmethyl in oily drops; *hydrobromic acid* acts in lik
hydriodic acid produces a yellow precipitate of the iodide; and *hydrosulph*
white precipitate of the sulphide. The oxide is not acted upon by hydroc
but is easily raised to a higher stage of oxidation by *nitric acid*, *mercuri*
silver-oxide. *Chlorine*, *bromine*, and *iodine* added to its solution in s
carbon, form precipitates which soon decompose. Corrosive sublimate does
to unite with it.

Arsenmethylic acid. $As(CH^3)H^2O^3$.—The barium-salt of this acid i
by decomposing the dichloride of arsenmethyl with a slight excess of sil
filtering from chloride of silver; treating the filtrate with excess of baryta-
moving that excess by carbonic acid; evaporating the filtered liquid to dr
the water-bath; dissolving the residue in a small quantity of water; and pr
by alcohol. The same salt may be obtained by decomposing the aqueous
oxide of arsenmethyl with mercuric oxide (for which purpose the alcoholi
obtained in the preparation of the oxide, *vid. sup.* may be used), decom
resulting mercurous salt with baryta, and proceeding as before.

By carefully decomposing the barium-salt with sulphuric acid and evapo
filtrate over the water-bath, arsenmethylic acid is obtained in the form
nated mass, resembling precipitated nitrate of urea. It is purified b
in hot alcohol, and crystallises, on cooling, in large spear-shaped laminæ, c
small needles, united in arborescent groups, permanent in the air, and not
any water of crystallisation. It is a strong acid, having a pure, sour, agree
and capable of decomposing carbonates. It is very soluble in water, and c
alcohol more readily than cacodylic acid. All its salts either crystallise or
cipitates. It is a dibasic acid, the formula of its normal salts being As(
The *barium-salt*, prepared as above, crystallises in colourless needles, contai
of water, which it gives up at 100° C. The anhydrous salt separates as a whi
composed of rhombic crystals, when the concentrated aqueous solution is
or mixed with alcohol. On examining with the microscope the precipitate
by alcohol, the rhombic crystals are seen to change in a few minutes int
needles of the hydrated salt. The salt is quite insoluble in alcohol, and ma
easily separated from cacodylate of barium, which is soluble in that liqui
methylate of silver, $As(CH^3)O^3Ag^2$, is precipitated in small crystals, havin
nacreous lustre, on mixing the neutral solution of the barium-salt with nitrat
It is anhydrous, is but little altered by exposure to air and light, does not
at 100° C., but explodes at higher temperatures, with rather strong detonati

Sulphide of Arsenmethyl, $As(CH^3)S$.—Obtained by passing sulphu
drogen into water in which dichloride of arsenmethyl is immersed:

$$As(CH^3)Cl^2 + H^2S = As(CH^3)S + 2HCl.$$

The chloride is then converted into a white mass of the sulphide, without th
separation of sulphur. The product is dissolved in a mixture of alcohol an
of carbon, from which it crystallises by rapid evaporation in shining lami
slow evaporation in small prisms. It is insoluble in water, moderately
alcohol and ether, very soluble in sulphide of carbon. In the crystallise
melts at about 100° C., but often remains fluid for a long time after cooli

d by heat, with separation of sulphide of arsenic. It is permanent in the
as a faint odour like that of asafœtida. The alcoholic solution decomposes
of silver, copper, lead, platinum, and mercurosum, with formation of me-
hides, and produces a white cloud with mercuric chloride.

OIMETHYL OF CACODYL. As(CH^3)^2 = Kd.—(Cadet, Crell. N. Chem. Arch.
unsen, Pogg. Ann. xl. 219; xlii. 145; Ann. Ch. Pharm. xxxvii. 6; xlii. 19;
Ann. Ch. Pharm. cvii. 257.—Gm. ix. 316; Gerh. i. 626.)—This body, together
products of its oxidation, constitutes the spontaneously inflammable liquid,
Cadet's fuming liquid or *alkarsin*.* To prepare this liquid, a mixture of equal
etate of potassium and arsenious oxide is distilled in a retort provided with a
rom which a long tube passes into the chimney, to carry away the poisonous
ved during the process. The retort is placed in a sand-bath and gradually
it is red-hot at the bottom. A brown oleaginous liquid consisting of im-
dyl is then found in the receiver, together with metallic arsenic, and a
water, acetone, and acetic acid, which floats on the top. The reaction is
licated, considerable quantities of carbonic anhydride and hydride of methyl
s) being given off, together with other gases in smaller quantity; but the
of cacodyl is evidently connected with the splitting up of acetic acid at a
nto carbonic anhydride and hydride of methyl (p. 12). The oily liquid,
very inflammable, is decanted by means of a syphon, the longer arm of
s under water. It is then washed with boiled water and distilled over
potassium in a current of hydrogen.

codyl is obtained by decomposing the chloride with metallic zinc, dissolving
hloride of zinc by water, and dehydrating the oily liquid, which sinks to
n, by distillation from chloride of calcium. The strong tendency of ca-
ke fire in the air and the extremely poisonous quality of its vapour, render
y to perform all the distillations in sealed vessels, filled with dry carbonic
Bunsen's method is as follows:

ide of cacodyl is prepared perfectly free from oxide, by distilling alkarsin
g hydrochloric acid, till the resulting chloride no longer emits the slightest
xposure to the air; or better, by mixing the dilute alcoholic solutions of
d mercuric chloride, and distilling the resulting precipitate of *chloromercurate*
(Kd^{2}O.2Hg″Cl^2) with very strong hydrochloric acid. To free the distillate
y either of these methods from water and hydrochloric acid, it is digested
days with a mixture of chloride of calcium and quick lime, contained in the
atus A (*fig.* 74). The air is first expelled from this apparatus by a stream
onic acid gas; the lower extremity *a* is then dipped into the chloride of
low the hydrochloric acid; the chloride of cacodyl is drawn into the bulb by
hand-syringe attached by a caoutchouc tube to the upper end *b*; and lastly
tus is sealed at both ends and set aside for several days.

ecomposition of the chloride of cacodyl is effected in a second apparatus *B*,
l in *fig.* 75. A moderately strong and rather wide gas-delivery tube is
to a bulb in two places *a*, *b*, about six inches apart; the lower extremity is
n out and twice bent, as shown at *c*, *d*: the upper bulb *a* is partly
ugh the wide open end of the tube with small cuttings of pure zinc-
pper end of the tube is then drawn out and bent, as shown in the figure,
ole apparatus is filled with perfectly dry carbonic acid gas. To introduce
d chloride of cacodyl into the bulb *a*, the tube of apparatus *A* is cut off
bove the bulb; the upper extremity *f* of the apparatus *B*, is then introduced
A; and a quantity of the liquid, sufficient to half fill it, is drawn in by
hand-syringe connected with the lower end *e*, after which the lower end
is sealed by the blowpipe at *e*, and the upper end sealed and melted off at *g*,
e bulb *a*. The apparatus is now inverted, and the bulb *a* immersed in
00° C. The reduction then takes place without evolution with gas, and
hours, the contents of the bulb *a* are converted into a white saline mass,
ars to be a compound of cacodyl with chloride of zinc, and melts to an
at 110°—120° C. To separate the cacodyl from the chloride of zinc, the

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ld was supposed by Bunsen to be the oxide of cacodyl, (AsC^{2}H^6)^{2}O. It does not appear,
be definite in constitution. Bunsen's analyses of it vary from 21·9 to 22·4 per cent. in the
from 65·4 to 66·2 in the arsenic. Dumas (Ann. Ch. Phys. [3] viii. 362) found 22·0 and 23·2
bon, and from 68·9 to 69·3 per cent. arsenic. Now the formula of oxide of cacodyl requires
and 66·4 arsenic, while that of cacodyl itself requires 22·9 carbon, and 71·4 arsenic. These
ults in accordance with the supposition that Cadet's liquid is a variable mixture of cacodyl
; the spontaneous inflammability of the liquid likewise indicates the presence of free caco-
e oxide of cacodyl (Bunsen's *paracacodylic oxide*, p. 407, supposed by him to be isomeric
n), produced by slow oxidation of cacodyl or of alkarsin itself, is not spontaneously inflam
rhardt.)

end *e* of the apparatus is broken off under water which has been thoroug
from air by boiling; the whole apparatus is heated to expel the carbonic anhyd
then left to cool, till the bulb *b* is nearly filled with water; the end *e* is agai
the apparatus inclined so that the water may flow into the bulb *a*; and this
gently heated. The chloride of zinc then dissolves, and the cacodyl sink
bottom as a heavy oily liquid.

Fig. 74.

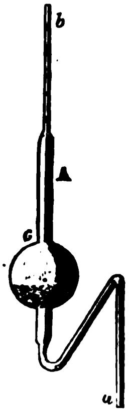
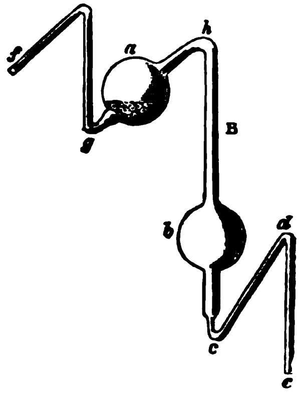


Fig. 75.



To dehydrate the cacodyl and purify it further, it is next transferred, with t
precautions as before, into another apparatus *A* (*fig.* 74), the bulb of which
dry chloride of calcium: for this purpose, the bulb *a* of apparatus *B* is cut off a
the apparatus *A* having been filled with dry carbonic acid gas, its lower extrem
introduced into the bulb *a*, and made to dip into the cacodyl below the watery
the cacodyl is then drawn by suction with the syringe into the bulb of appa
which is then sealed at both ends, and set aside for some time. The deh
cacodyl is next transferred into a second apparatus B, filled with dry carbo
gas, and having some zinc-cuttings in the bulb *a*, and the two arms of the tu
then sealed and melted off just below the bulbs *a*, *b*. The bulb *b* is then imm
cold water; the cacodyl distilled into it by gently heating the bulb *a* with
lamp, and then poured back; and the rectification is repeated in this manner two
times. Lastly, the bulb *b* is cooled in a freezing mixture to $-6°$ C., and left t
about $\frac{3}{4}$ of the liquid has crystallised, and the still liquid portion is poured ba
which then remains in the solid state is pure cacodyl.

Cacodyl may also be prepared by heating the sulphide with mercury.

Properties.—Cacodyl is at ordinary temperatures a transparent colourless, stro
fracting liquid, heavier than water. It boils near 170° C. Its vapour-density (
to air as unity) is by experiment 7·101, which shows that the formula of ca
the free state is $As^2C^4H^{12} = As^2Me^4 = KdKd$. For the atomic weight rep
by this formula is 210 ($= 2 . 75 + 4 . 12 + 12 . 1$), and if this represents 2
vapour, the weight of one vol. of vapour, that is to say, the specific gravity re
hydrogen as unity, is 105; and multiplying this by 0·0693, the specific g
hydrogen referred to air, we obtain for the specific gravity of cacodyl-vapour
to air as unity, the number 7·2755, which is very near the number determ
experiment. Cacodyl has a disgusting odour, somewhat like that of arsenette
gen, and its vapour is very poisonous. It solidifies at 6° C. in square-based pri
is sparingly soluble in water, very soluble in alcohol and in ether. When hea
close vessel to about 400° C. it is resolved, without deposition of carbon, into
arsenic, and a mixture of 2 vol. marsh gas and 1 vol. olefiant gas:

$$As^2C^4H^{12} = 2CH^4 + C^2H^4 + As^2.$$

Cacodyl takes fire in the air, at ordinary temperatures, even more readily th
alkarsin, yielding carbonic anhydride, water, and arsenious oxide, but if the
of air present is not sufficient for complete combustion, a red compound,
erythrarsin, is formed at the same time. This red substance is also produce
cacodyl is passed through red-hot tubes; also by the action of protochlorid
or phosphorous acid on cacodyl. It appears to contain $C^4H^{12}As^4O^3$. Cacodyl

to the gradual action of *oxygen*, as when air is passed into it in successive bubbles, is converted first into oxide of cacodyl, and afterwards into cacodylic acid. It takes fire in *chlorine gas*, and is converted by chlorine-water into chloride of cacodyl. It dissolves *sulphur*, forming a protosulphide or trisulphide of cacodyl, according to the quantity. *Fuming sulphuric acid* dissolves it without blackening: the solution gives off, even in the cold, a considerable quantity of sulphurous acid, and yields by distillation a product having an agreeable ethereal odour. It dissolves in *nitric acid*, and the solution yields with *nitrate of silver* a crystalline precipitate of nitrate of silver and cacodyl.

Bromide of Cacodyl, $As(CH^3)^2Br = KdBr$, is obtained by distilling the chloromercurate, $As^2C^4H^{12}O.2HgCl^2$, with concentrated hydrobromic acid, and is purified like the chloride. It is a yellow liquid, which does not fume in the air, and closely resembles the chloride. When heated over mercury to a temperature between 200° and 300° C. it is decomposed, yielding free cacodyl and mercurous bromide. Heated with water it forms an *oxybromide*.

Chloride of Cacodyl, $As(CH^3)^2Cl = KdCl$.—Prepared by distilling the chloromercurate with very strong hydrochloric acid, and purified from water and adhering hydrochloric acid by placing it in contact with chloride of calcium and quick lime, and distilling it in the hermetically sealed apparatus (*fig.* 74) filled with dry carbonic anhydride. It is also produced by the action of chlorine-water on cacodyl. It is a very mobile liquid, heavier than water, which does not solidify even at $-45°$ C. It boils a little above 100° C., forming a colourless vapour of specific gravity 4·56 (by calculation 4·85). It does not fume in the air, but emits a very pungent intoxicating odour. The vapour mixed with air produces, when inhaled in rather large quantity, swelling of the mucous membrane of the nose and extravasation of blood in the eyes. The vapour evolved from the boiling liquid takes fire spontaneously in the air, and explodes violently when heated with oxygen gas.

Chloride of cacodyl is insoluble in *water* and *ether*, but soluble in all proportions in *alcohol*. *Sulphuric* and *phosphoric acids* decompose it, eliminating hydrochloric acid. Strong *nitric acid* sets it on fire. It burns in *chlorine* gas, with copious deposition of charcoal. *Zinc*, *tin*, and *iron* decompose it, setting the cacodyl free. With *alcoholic potash* it yields chloride of potassium, and an ethereal liquid having a disagreeable odour, and miscible in all proportions with water and alcohol. Mixed with solution of *nitrate of silver*, it gives up the whole of its chlorine, forming a precipitate of chloride of silver.

A *subchloride* or *oxychloride of cacodyl*, $KdCl.xKd^2O$, is obtained by the action of water on the chloride, also by distilling alkarsin with dilute hydrochloric acid, rectifying the product over a mixture of chalk and water, and redistilling in an atmosphere of carbonic anhydride. It is a liquid which resembles the chloride, has a very offensive odour, and boils at 109° C., giving off a vapour of specific gravity 5·46.

Chlorocuprite of Cacodyl, $2KdCl.Cu^2Cl^2$, is obtained as a bulky white precipitate, on mixing an alcoholic solution of chloride of cacodyl with a solution of cuprous chloride in hydrochloric acid. In contact with the air, it turns green, and gives off very fetid arsenical vapours. It is decomposed by heat into its component chlorides.

Chloroplatinate of Cacodyl.—An alcoholic solution of chloride of cacodyl mixed with tetrachloride of platinum, yields a red-brown precipitate, probably consisting of $2AsC^2H^6Cl.PtCl^4$; but on boiling this product with water, a yellow solution is obtained, which on cooling deposits crystals of a new compound, viz.:

Chloride of Cacoplatyl, $As^2C^4H^8Pt^{iv}Cl^2.2H^2O$, that is to say, the chloride of a radicle, cacoplatyl, formed from cacodyl by substitution of 1 atom of quadrivalent platinum for 4 at. hydrogen. The anhydrous compound might be formed from 1 molecule of chloroplatinate of cacodyl by abstraction of 4HCl. This salt forms needle-shaped crystals, which are inodorous, have a nauseous taste, and are soluble in hot water and alcohol. Ammonia dissolves it in all proportions, and the solution when evaporated yields indistinct crystals insoluble in alcohol. Chloride of cacoplatyl sustains a temperature of 164° C. without decomposing, merely giving off 4 per cent. of water, which it takes up again when boiled with water. At higher temperatures, it turns brown, and then burns away, giving off arsenical vapours and leaving arsenide of platinum. Chloride of cacoplatyl is not attacked by hydrochloric acid; sulphuric acid colours it yellow. With iodide and bromide of potassium, it forms yellow precipitates of *iodide* and *bromide of cacoplatyl*, precisely similar in composition to the chloride. With nitrate of silver, it forms a precipitate of chloride of silver, the liquid remaining neutral. Boiled with sulphate of silver, it also forms chloride of silver, and the filtered solution evaporated in vacuo yields white crystalline grains of *sulphate of cacoplatyl*, $(AsC^2H^4Pt'')^2.SO^4$. (Gerh. i. 642.)

Trichloride of Cacodyl, $As(CH^3)^2Cl^3$.—Produced: 1. By the action of perchlor phosphorus on cacodylic acid:

$$KdO^2H + 2PCl^5 = KdCl^3 + 2PCl^3O + HCl.$$

The chloride of phosphorus must be immersed in anhydrous ether, the cacodyli in powder added by small portions at a time, and the action moderated by ext cooling.—2. By the action of chlorine on the monochloride. The latter comp when brought directly in contact with chlorine gas, takes fire and undergoes com decomposition; but if chlorine be led on to the surface of a solution of the chloride in sulphide of carbon externally cooled, the trichloride is formed in cryst laminæ, which may be purified by washing with sulphide of carbon.

The trichloride, prepared by the first method, forms beautiful large prismatic tals, which, however, are very unstable, being instantly decomposed, at tempera between 40° and 50° C., into chloride of methyl and dichloride of arsen-monome

$$As(CH^3)^2.Cl^3 = As(CH^3)Cl^2 + CH^3Cl.$$

The decomposition takes place spontaneously in the course of a day at ordinary peratures, even when the compound is enclosed in sealed tubes. The crystals obt by the second method are much more stable.

Trichloride of cacodyl dissolves without decomposition in anhydrous ether, and rates by quick cooling of a warm saturated solution, in laminæ, by slow coolin spontaneous evaporation, in transparent colourless prisms, which, however, become even in a vacuum. It dissolves less freely in sulphide of carbon, from which it rates in large laminæ. Anhydrous alcohol decomposes it, forming a syrup, whic slow evaporation, yields crystals of basic perchloride of cacodyl, or hydrochlora cacodylic acid:

$$As(CH^3)^2Cl^3 + 2(C^2H^5.H.O) = \underbrace{As(CH^3)^2O^2H^2Cl}_{\text{Basic perchloride of cacodyl.}} + \underbrace{2C^2H^5Cl.}_{\text{Chloride of ethyl.}}$$

The alcoholic solution, left to evaporate, gives off a substance, probably *dichlori arsen-monomethyl* (p. 401), which acts intensely on the mucous membranes. The chloride fumes in moist air, giving off hydrochloric acid, and forming basic perchl of cacodyl. The same decomposition takes place in the ethereal solution whe posed to the air, the basic perchloride separating in long needles, the formati which may be accelerated by the addition of water or alcohol. The trichloride solves in water, with considerable rise of temperature, forming a solution of caco acid and hydrochloric acid:

$$As(CH^3)^2Cl^3 + 2H^2O = As(CH^3)^2O^2H + 3HCl.$$

The decomposition is exactly similar to the preceding, the basic perchloride contai indeed the elements of cacodylic and hydrochloric acid:

$$As(CH^3)^2O^2H^2Cl = As(CH^3)^2O^2H + HCl.$$

The ethereal solution of the trichloride does not attack *mercuric oxide;* but on ad alcohol, a brisk action takes place, and an oil separates which contains chlorine mercury, is soluble in alcohol, and precipitated by ether. On further additio mercuric oxide, the whole solidifies to a mass of corrosive sublimate, and the comp of that substance with cacodylic acid (p. 408). Oxide of silver is also without a on the ethereal solution. (Baeyer.)

Dibromochloride of Cacodyl, $As(CH^3)^2ClBr^2$.—Bromine acts upon monochlorid cacodyl in the same manner as chlorine. On adding bromine to a mixture of monochloride and sulphide of carbon, the dibromochloride is precipitated in the of a yellow crystalline body, which is even more unstable than the trichloride, b quickly resolved into gaseous bromide of methyl, and a liquid which appears t chlorobromide of arsen-monomethyl, $As(CH^3)^2.ClBr$, but is very unstable. (Baey

Cyanide of Cacodyl, $As(CH^3)^2.CN = KdCy$, is obtained by distilling alk (Cadet's liquor) with strong hydrocyanic acid, or better with a concentrated tion of cyanide of mercury; metallic mercury then separates, and cyanide of cac collects under the water in the receiver, in the form of a yellowish oil, which solidifies in fine prismatic crystals. The liquid is decanted, and the crystals are by pressure between bibulous paper. The crystals are oblique prisms, truncated on acute edges, and terminated by dihedral summits. It melts at 33° C., forming a col less ethereal, strongly refracting liquid, which solidifies again on cooling. It boi 140° C., yielding a vapour of specific gravity 4·63. It dissolves sparingly in water, m more readily in alcohol and ether. It is intensely poisonous, more so than any o cacodyl-compound. A few grains of it diffused in vapour through the air of a ro

t to excite giddiness, delirium, numbness of the hands and feet, and even
ciousness; these attacks, however, are of short duration, provided the
ted make his escape in time. Cyanide of cacodyl is not decomposed by
is, but *concentrated acids* decompose it, with evolution of hydrocyanic
silver-solutions it forms a precipitate of cyanide of silver. It reduces
itrate, but does not act on mercuric nitrate. With *mercuric chloride*, it
te precipitate of chloromercurate of cacodyl.

e of **Cacodyl**, $As(CH^3)^2F$ = KdF.—Produced by distilling the chloro-
vith hydrofluoric acid. It is a colourless liquid, which has an offensive
ttacks glass.

f **Cacodyl**, $As(CH^3)^2I$ = KdI.—When alkarsin is distilled with concen-
odic acid, an oily liquid passes over, which on cooling deposits transparent
tables, consisting of *oxyiodide of cacodyl*. To complete the separation, the
nersed in a freezing mixture, then decanted from the crystals, and afterwards
ectified in the manner described for the chloride, the distillation being, how-
inued when two-thirds of the liquid have passed over. Iodide of cacodyl thus
a yellowish, slightly syrupy liquid, having a strong repulsive odour. It is
n melted chloride of calcium. It remains liquid at −10° C., and boils at a
above 100° C.; nevertheless it distils with the vapour of water. It does
nen exposed to the air, but gradually oxidises and deposits fine prismatic
cacodylic acid. It is soluble in *alcohol* and *ether*, but insoluble in water.
sulphuric acids decompose it, setting iodine free. When heated in the air
h a dazzling flame, giving off vapours of iodine.

f **Cacodyl**, $As^2C^4H^{12}O = Kd^2O$. (Bunsen's *Paracacodylic Oxide*, see p.
compound is formed by the slow oxidation of cacodyl; also by the action of
ents, such as hydriodic, hydrobromic, sulphydric, or phosphorous acid,
e of tin, &c., on cacodylic acid. When air is made to bubble slowly through
t liquid is gradually converted into a syrup filled with crystals of caco-
and on dissolving in water the mass thus obtained, and distilling, water
odour of cacodyl passes over at first, and afterwards between 120° and
oily liquid, which when dried over caustic baryta, and rectified out of con-
yields pure oxide of cacodyl, in the form of a limpid oil, having a pungent
ngly soluble in water, and boiling at 120° C. When exposed to the air, it
y slowly, without fuming or rise of temperature, and is converted into
id. Air mixed with its vapour between 50° and 70° C. detonates violently
oach of a burning body. Oxide of cacodyl dissolves in hydrochloric, hy-
hydrobromic acids, forming the chloride, bromide, and iodide of cacodyl.
cacodyl forms with *mercuric chloride*, a white precipitate, which is a com-
two substances $Kd^2O.2Hg''Cl^2$. This compound, called **chloromercurate**
l, is also produced by mixing a dilute alcoholic solution of alkarsin with
lution of mercuric chloride, the latter not being in excess. After several
ons from boiling water, it forms silky tufts, and by slow cooling of the
y be obtained in small rhombic tables; 100 pts. of boiling water dissolve
the compound: it is also soluble in alcohol, especially at the boiling heat.
ous, but has a disagreeable metallic taste, and is very poisonous. When
ontact with the air, it decomposes without leaving any residue. With
, hydriodic, and hydrobromic acids, it forms chloride, iodide, and bromide

cacodyl forms with *mercuric bromide*, a compound similar in composition
ties to that just described, viz. the **bromomercurate of cacodyl**,
$3r^2$. With *nitrate of silver*, it forms the compound $3Kd^2O.2NO^3Ag$, which
the form of a heavy, white, crystalline powder, on pouring a solution of
lver into a cold solution of alkarsin in dilute nitric acid. This compound
emperature of 90° C. without decomposing, but explodes at 100° C., giving
enical products. With *tetrachloride of platinum*, oxide of cacodyl forms a
precipitate, and with *cyanide of mercury* a brown pulverulent precipitate,
paracyanogen and smelling like dried nightshade berries.

f Cacodyl, AsC^2H^6O = KdO, or *Cacodylate of Cacodyl*, $\left.\begin{matrix}Kd\\Kd\end{matrix}\right\}O^2$—This
syrupy liquid which is produced by the slow oxidation of cacodyl or alkar-
dually becomes filled with crystals of cacodylic acid. It is decomposed by
the liquid then yields a distillate of oxide of cacodyl, and leaves a residue
acid:

$$4KdO + H^2O = Kd^2O + 2KdO^2H.$$

ic Acid, $AsC^2H^7O^2 = KdO^2.H$, or $Kd^2O^3.H^2O$.—This compound may be

prepared by passing oxygen gas for several days through alkarsin; the greater pa
liquid is then converted into crystals of cacodylic acid, which may be purified by
between paper and recrystallisation. This mode of preparation, however, is d
able and dangerous, on account of the inflammability and poisonous characte
cacodyl. A safer and more expeditious method is to oxidise alkarsin with
oxide. The two substances are placed together under water, in a vessel ex
cooled; mercury is thereby reduced, and cacodylate of mercury formed:

$$2Kd + 4Hg''O = 3Hg + Hg''(KdO^2)^2.$$

More alkarsin is then added, drop by drop, till mercury no longer separates on
the mixture, and a faint odour of cacodyl becomes perceptible; after which th
is evaporated, the residue dissolved in alcohol, and the cacodylic acid which cry
from the solution is purified by recrystallisation from alcohol. It is then obt
large oblique rhomboidal prisms, transparent and colourless. It is inodorous
at all poisonous, although it contains 54·35 per cent. of arsenic. It dissolves
in all proportions, somewhat less freely in alcohol, and is insoluble in ether
permanent in dry air, but damp air decomposes it. It is altogether a ver
compound, sustaining a heat of 200° C. without decomposition; at higher t
tures however, it decomposes, yielding arsenious oxide and other arsenical
having a very fetid odour. It is not attacked by fuming nitric acid, or by a
of sulphuric acid and chromate of potassium, even at the boiling heat. It is no
dised by sulphurous acid, oxalic acid, ferrous sulphate, or hydrogen gas; b
heated with *phosphorous acid*, it gives off vapours of cacodyl. It is also reduced
aqueous solution is boiled with *zinc*. An acid solution of *protochloride of tin* co
into chloride of cacodyl. Dry *hydriodic acid* gas, passed over dry cacodylic aci
iodide of cacodyl, water, and free iodine:

$$KdO^2H + 3HI = KdI + 2H^2O + 2I.$$

Dry *hydrobromic acid* gas acts in a similar manner. With dry *hydrochloric*
the contrary, or with the concentrated aqueous acid, cacodylic acid unites
forming the compound $KdO^2H.ClH$. But by exposing cacodylic acid for some
a stream of hydrochloric acid gas, *dichloride of arsenmonomethyl* is obtained,
with water and chloride of methyl. (Baeyer):

$$As(CH^3)^2O^2H + 3HCl = AsCH^3Cl^2 + 2H^2O + CH^3Cl.$$

Sulphydric acid, either dry or in aqueous solution, decomposes cacodylic ac
rise of temperature, forming disulphide of cacodyl, water, and sulphur:

$$2KdO^2H + 3H^2S = 2KdS + 4H^2O + S;$$

but if the cacodylic acid is dissolved in weak alcohol, a considerable quantity o
sulphide is formed as well as disulphide:

$$2KdO^2H + 3H^2S = Kd^2S + 4H^2O + 2S.$$

Cacodylates.—Cacodylic acid dissolves metallic oxides, and decomposes ca
with effervescence. Most of its salts are gummy, but few being capable of
lising. The general formula of the normal cacodylates is $AsC^2H^6MO^2$ =
They require a higher temperature to decompose them than the acid, and
stinking products, leaving a residue of carbonate or arsenate. They dissolve i
and in alcohol. Sulphydric acid converts them into the corresponding *sulpho-*
lates KdS^2M. With *silver*, cacodylic acid forms a normal salt, KdO^2Ag, and
salt, $KdO^2Ag.2KdO^2H$, both of which crystallise in needles.

Cacodylic acid also combines with certain *acids*.

Hydrochlorate of cacodylic acid, $KdO^2H.ClH$, called by Bunsen, *basic perchl*
cacodyl, is obtained by dissolving cacodylic acid in concentrated hydrochloric a
evaporating in vacuo. It then solidifies in a mass of beautiful lamellated cryst
odorous, but having a strong acid taste (Bunsen). It is also produced by the
of water or alcohol on trichloride of cacodyl (Baeyer, p. 406). The comp
decomposed by water into hydrochloric and cacodylic acids, and when he
200° C. gives off monochlorinated hydride of methyl, water, hydrochloric ac
an oily liquid, leaving a residue of arsenious acid.

On mixing the alcoholic solutions of cacodylic acid and mercuric chloride,
dylate of mercuric chloride, $Kd^2O^3.2HgCl$, is precipitated in white shining
which change after a while to slender needles.

Hydrofluoric acid forms with cacodylic acid a similar compound, $KdO^2H.FH$
crystallises in fine prisms. *Hydrobromic acid* also unites directly with cacodyl
but the compound is a syrupy liquid which does not crystallise.

Selenide of Cacodyl, is obtained by distilling chloride of cacodyl two
times with aqueous selenide of sodium. It passes over with the vapour of w
the form of a heavy yellow oil, having an extremely offensive odour. It is i

soluble in alcohol and ether. It has a very high boiling point. It forms
ates with *lead* and *silver* salts, and with *mercuric chloride*, it yields first
pitate of sulphide of mercury, and afterwards, on further addition of the
a copious precipitate of chloromercurate of cacodyl.

of Cacodyl, $As^2C^4H^{12}S$ = Kd^2S, may be prepared by adding a solution of
rium to the crude liquid obtained by distilling acetate of potassium with
le, or by distilling sulphydrate of barium with chloride of cacodyl. It is
eans of carbonate of lead and chloride of calcium. It is a transparent,
remely fetid liquid, which retains its fluidity at 40° C., and boils at a tem-
derably above 100°, yielding a vapour of specific gravity 7·72. It is nearly
ater, but mixes in all proportions with alcohol and ether. It does not
r, but rapidly absorbs oxygen, being converted into dioxide and disul-
yl:

$$Kd^2S + O = KdO + KdS.$$

acid converts it into chloride of cacodyl, with evolution of sulphydric

of Cacodyl, KdS, or *Sulphocacodylate of cacodyl*, $\left.\begin{matrix}Kd\\Kd\end{matrix}\right\}S^2$.—Obtained by
ulphur on cacodyl, or on the monosulphide, or by treating cacodylic acid
cted hydrogen in a vessel externally cooled. Disulphide of cacodyl then
ed with excess of sulphur, from which it may be separated by solution
ohol. The solution, if slowly cooled, deposits the disulphide in large
, but if quickly cooled, in small prisms, soft and greasy to the touch.
l has a pungent odour, like that of asafœtida, is permanent in the air,
0° C., forming a colourless liquid, which solidifies in a crystalline mass on
insoluble in water, but dissolves readily in alcohol, very sparingly in
olves in hydrochloric acid without alteration; in strong sulphuric acid,
of sulphurous acid and separation of sulphur. Nitric acid and peroxide
t it into cacodylic acid. Mercury decomposes it, forming protosulphide
l sulphide of mercury.

odylic acid, $AsC^2H^7S^2$ = KdS^2H.—This acid has not been obtained in
but its salts, KdS^2M, are obtained by precipitating the alcoholic solution
ide with alcoholic solutions of certain metallic salts, or by decomposing
s with sulphydric acid. The *lead-salt*, Kd^2S^4Pb'', forms small white
which are inodorous, permanent in the air, not affected by sulphydric
in water, nearly insoluble in alcohol. The *cuprous salt*, $Kd^2S^4(Cu^2)''$,
is obtained by adding an alcoholic solution of cupric nitrate to a large
holic disulphide of cacodyl, cacodylic acid and nitrate of cacodyl being
same time:

$$(NO^3)^2Cu'' + 2H^2O = Kd^2S^4(Cu^2)'' + KdO^2H + NO^3Kd + 3NO^3H.$$

oose, egg-yellow powder, which is decomposed by heat, and is insoluble
us acids, alcohol, and ether. The *antimony-salt*, Kd^3S^6Sb (Sb being equi-
, crystallises in short light yellow needles, difficult to purify. The
Kd^3S^6Bi, forms delicate, golden-yellow, inodorous scales, which are per-
air, sustain a heat of 100° C. without decomposition, and are not affected
acid. They are insoluble in water, and nearly insoluble in alcohol
he *gold-salt*, KdS^2Au, is obtained by mixing the alcoholic solutions of
cacodyl and trichloride of gold, cacodylic acid being formed at the same
, yellowish white, tasteless, inodorous powder, which is set on fire by
cid, with separation of sulphur and gold. It is decomposed by caustic
t by sulphydric acid. Insoluble in water, hydrochloric acid, alcohol and

METHYL $As(CH^3)^3$ and ARSENMETHYLIUM $As(CH^3)^4$. (Cahours and
, rend. xxxix. 541.)—When iodide of methyl is dropped by small portions
ask filled with carbonic anhydride and containing pulverised arsenide of
iderable degree of heat is developed; and if the additions of iodide of
eated till no further rise of temperature is produced, and the mixture be
in a current of carbonic anhydride, four products are obtained, viz. unal-
methyl, a white crystalline body, and a heavy liquid composed of two dis-
ds, one of which boils at 120° C., the other between 165 and 170°. The
trimethyl; the latter arsendimethyl or cacodyl. The quantity of these
ed is but small, even when the matter operated upon amounts to 100

ethyl is obtained pure by the decomposition of iodide of arsenmethylium, *e.g.* by treating the compound of iodide of arsenmethylium and io arsenic (*vid. inf.*) with boiling potash-ley, evaporating to dryness, and distil an atmosphere of carbonic anhydride. It is a colourless mobile liquid, boilin 100° C. It is diatomic. The *oxide*, $AsMe^3O$, is crystallisable but deliquescen *sulphide*, $AsMe^3S$ crystallises from aqueous or alcoholic solution by slow evap in colourless prisms. It unites already with iodine and bromine, forming th pounds $AsMe^3I^2$ and $AsMe^3Br^2$. (Cahours, Compt. rend. xlix 87; Jal d. Chem. 1859, 431.)

Iodide of Arsenmethylium.—This is the crystallised body just men which is in fact the chief product of the reaction. It may also be obtained action of iodide of methyl upon cacodyl. On mixing these two liquids in a violent action takes place, and a yellowish white mass of crystals of iodide o methylium is obtained, impregnated with an oily matter of the same colour, co of iodide of cacodyl:

$$2CH^3I + 2As(CH^3)^2 = As(C^2H^3)^4I + AsC^2H^6.I.$$

The crystals, freed from the oil by draining and pressure between bibulous pap then dissolved in iodide of methyl mixed with alcohol, separate from the sol the form of beautiful colourless tables having a high lustre.

Iodide of arsenmethylium boiled with recently precipitated oxide of silver, y strongly alkaline liquid, which, when evaporated in vacuo, yields very deliq crystalline laminæ consisting of the *hydrated oxide of arsenmethylium;* and its mixed with sulphate or nitrate of silver, yields iodide of silver, and *sulphate* o methylium, $SO^4(AsMe^4)^2$, or the *nitrate*, NO^3AsMe^4. These salts are very soluble deliquescent, and separate from their solutions by evaporation in vacuo, in the beautiful crystals.

Iodide of Arsenmethylium with Tri-iodide of Arsenic $As(CH^3)^4I$. When iodide of methyl is heated to 200° C., in contact with metallic arsenic, th disappears, and a large quantity of orange-red tabular crystals are obtained, mo with a brownish liquid.

The crystals are decomposed by distillation, yielding an oil which has a pen odour and excites tears. This oil is a mixture of several substances, the least of which boils at 170° C., has the composition of iodide of cacodyl, and yields when distilled with amalgam of zinc; the more volatile portion deposits lon very beautiful needles, isomeric with iodide of cacodyl.

Iodide of Arsenmethylium and Zinc, $2As(CH^3)^4I.Zn''I^2$, is obtained in less crystals by heating iodide of methyl with arsenide of zinc. It is deco by boiling with potash-ley, a heavy oil separating, which solidifies on cooling, this mass be exposed to the air till the free potash is converted into carbonat exhausted with absolute alcohol, and the alcohol left to evaporate, iodide of methylium crystallises out in prisms. (Cahours, Compt. rend. xlix. 87.)

Iodide of Arsenmethylium and Cadmium, $2As(CH^3)^4I.Cd''I^2$, is obta like manner and exhibits similar properties. (Cahours.)

Tri-iodide of Arsenmethylium, $As(CH^3)^4I^3$.—Analogous to tri-iodide ethylium. (Cahours.)

Bromide of Arsenmethylium.—Bromide of methyl acts energetic cacodyl, yielding bromide of arsenmethylium in beautiful, very deliquescent c and liquid bromide of cacodyl. (Cahours and Riche.)

ARSENDIMETHYL-DIETHYLIUM. $As(CH^3)^2(C^2H^5)^2 = AsMe^2E^2$.—(Cahou Riche, Compt. rend xxxix. 544.)

This radicle, like the preceding, has not been obtained in the free state, sulphide, iodide, bromide, and chloride are formed, together with the corresp compounds of cacodyl, by the action of sulphide, iodide, &c., of ethyl on cacod

Iodide. $As(CH^3)^2(C^2H^5)^2I$.—When iodide of ethyl is mixed with caco apparent change takes place at first; but the mixture, when left to itself, gr deposits magnificent crystals of iodide of arsendimethyldiethylium, and likewis an oil consisting of iodide of cacodyl:

$$2EI + 2AsMe^2 = AsMe^2E^2I + AsMe^2I.$$

Bromide and *Chloride of ethyl* act in a similar manner, but more slowly. To *chloride of arsenmethyl-ethylium*, the mixture must be heated in sealed tubes or 200° C.; it then deposits an oil containing needle-shaped crystals of the ch On distilling the oil and leaving the distillate to cool, these crystals separate in

loride of arsendimethyldiethylium forms crystalline compounds with
rcury, trichloride of gold, and dichloride of platinum.

te is formed by treating a solution of the iodide with oxide of silver; a
ne liquid is then obtained, which, when evaporated, deposits the oxide
escent crystalline scales.

—Sulphide of ethyl acts very slowly on cacodyl, and only when heated,
lline sulphide of arsendimethyldiethylium and a yellowish oil, consisting
cacodyl.

ate and *Nitrate* are obtained in the form of very deliquescent
eating the solution of the iodide with sulphate or nitrate of silver.

METHYL-ETHYLIUM, $AsMe^3EI$, and **ARSENMETHYL-TRIETHYLIUM**,
e iodides of these radicles are obtained by treating arsentrimethyl with
yl, and arsentriethyl with iodide of methyl respectively. Both are
vith the iodides of arsentetramethylium and arsentetrethylium.

ETHYL-DIAMYLIUM, $As(C^2H^3)^2(C^5H^{11})^2 = AsMe^2Am^2$.—The iodide of
produced, together with iodide of cacodyl, by heating cacodyl with iodide
° C. for two or three days. It crystallises either in nacreous needles, or
Treated with oxide, nitrate, and sulphate of silver, it yields the *oxide*,
lphate of arsendimethyldiamylium. (Cahours and Riche.)

es of methyl and their compounds are related to one another by the fol-
If we arrange them in two groups, the one formed on the type of chloride
NH^4Cl, the other on that of ammonia, NH^3, as in the following tables,
each member of the second column may be derived from the one next
first, by abstraction of chloride of methyl; and each member in the first
the highest, may be formed from the one next above it in the second,
2 atoms of chlorine, the series extending from chloride of arsentetrame-
chloride of arsenic:

Type NH^4Cl.	*Type* NH^3.
As Me Me Me Me Cl	As Me Me Me
As Me Me Me Cl Cl	As Me Me Cl
As Me Me Cl Cl Cl	As Me Cl Cl
As Me Cl Cl Cl Cl	As Cl Cl Cl

tions indicated in this table have been actually observed, excepting the
$AsMe^4Cl$ into $AsMe^3$ and MeCl, and that of $AsMe^3Cl^2$ into $AsMe^2Cl$ and
decomposition analogous to the former of these, appears to take place in
n of the iodides of the arsenmethyls and arsenethyls, the iodide of arsen-
arsenethylium being formed at first, and then resolved by distillation
methyl or ethyl, and arsentrimethyl or arsentriethyl, just as iodide of
$N(C^2H^5)^4I$, is resolved under similar circumstances into iodide of ethyl
nine.

so another relation to be observed between these compounds, viz. that
may be derived from the one immediately above it in the same column,
n of chlorine for methyl; and hence it appears that $AsMe^4$ is monatomic;
ic; $AsMe^2$ either monatomic or triatomic; and AsMe either diatomic or
ust as in chloride of propyl, C^3H^7Cl, the radicle C^3H^7 replaces 1 at. hydro-
in chloride of propylene, $C^3H^6Cl^2$, derived from the former by substitution
I, the radicle C^3H^6 takes the place of 2 atoms of hydrogen; and in tri-
$C^3H^5Cl^3$, the next term in the same series, C^3H^5 (glyceryl), takes the
H. Moreover, just as the group C^3H^5 is monatomic in the allyl-com-
riatomic in the glyceryl-compounds, so likewise $As(CH^3)^2$ is sometimes
nd sometimes triatomic. The analogy between the two series of com-
e more clearly seen from the following tabular view:

$$As(\overset{\prime}{C}H^3)^2 \,.\, Cl \qquad \overset{\prime}{C}{}^3H^7 \,.\, Cl$$

$$As(\overset{\prime\prime}{C}H^3)^2 \,.\, Cl^2 \qquad \overset{\prime\prime}{C}{}^3H^6 \,.\, Cl^2$$

$$As(\overset{\prime\prime\prime}{C}H^3)^2 \,.\, Cl^3 \qquad \overset{\prime\prime\prime}{C}{}^3H^5 \,.\, Cl^3$$

$$As(\overset{\prime}{C}H^3)^2 \quad Cl. \qquad \overset{\prime}{C}{}^3H^5 \,.\, Cl.$$

alogies may be traced in the compounds of arsenic and ethyl, and like-
not yet quite so clearly, in the compounds of antimony, bismuth, and
vith the alcohol-radicles. (Baeyer.)—In fact, the compounds of these
dicles may, in almost all cases, be reduced to the general types MR^3,
M^2R^5, where M stands for P, As, Sb, or Bi; and the 3 or 5 at. R are made

up, partly by an alcohol-radicle, partly by an equivalent quantity of chlori
oxygen, sulphur, &c. (See ORGANO-METALLIC BODIES.)

Arsenide of Tetryl. *Tetryl- or Butyl-cacodyl. Cacodyl of Valer*
When valerate of potassium is distilled with an equal weight of arsenio
heavy yellowish oil passes over, which has a penetrating alliaceous od
copiously in the air, but does not take fire spontaneously. It is soluble in w
a thick white precipitate with mercuric chloride, and appears to reduce mer
to the metallic state. When left for some time in a loosely closed vessel,
entirely into a mass of large, hard, shining, nearly colourless, prisms, w
drying between filtering paper, are destitute of odour. They have an aci
dissolve in water, and are completely decomposed by nitrate of silver. (G
Am. J. [2] xv. 118.)

Arsenide of Trityl. *Trityl- or Propyl-cacodyl. Cacodyl of Butyric*
distilling equal weights of butyrate of calcium and arsenious oxide, shaki
distillate with magnesia and water, and rectifying, a heavy colourless oi
obtained, which has a disgusting cacodyl-odour, does not fume in the air,
when set on fire with a white flame and arsenical smoke. The watery li
passes over with the oil, appears to contain a considerable quantity of it, a
white precipitate with mercuric chloride, the cacodyl-odour being at the
destroyed. The precipitate dissolves on heating the liquid, but reappear
crystals on cooling. On mixing the solution and the crystals with hydro
and zinc, the odour of cacodyl reappears, the evolved hydrogen gives off t
fumes in the air, and deposits an orange-coloured substance on cold bo
mixture when heated yields a colourless fœtid oil, which fumes in the air,
spontaneously inflammable. (Wöhler, Ann. Ch. Pharm. lxviii. 127.)

ARSENIOSIDERITE. *Arsenocrocite.* A hydrated ferrico-calcite
occurring at Romanèche, near Macon, in spherical masses of fibrous texture
colour. Its exact composition has not been determined.

ARSENITE or **ARSENOLITE.** *Arsenic bloom. Native Arseniou*
A rare mineral, generally occurring in needle-shaped or capillary crystals, al
with spherical and botryoïdal surface; very rarely in regular octahedrons
gravity = 3·69 to 3·71. Hardness = 1·5. It consists of arsenious oxide n
pure, has a white to greyish-white colour, occasionally yellow, red, or green;
covered with a blackish crust (? suboxide or a mixture of arsenious oxide wi
arsenic). It is translucent, with vitreous to silky lustre. It is found, acc
ores of silver, lead, arsenical iron, cobalt, nickel, &c., at Andreasburg in
also at Joachimsthal in Bohemia, Kapnik in Hungary, and in the old min
in Hanau. (Dana, ii. 139.)

ARSENOMELANE. See BINNITE.

ARSENOPYRITE. Syn. with MISPICKEL.

ARSENOSIDERITE. Native diarsenide of iron. (See IRON, ARSE

ARSENPHYLLITE. Breithaupt's name for a mineral which, accord
has the composition of arsenious oxide, but crystallises in forms of th
system, isomorphous with valentinite. The trioxides of arsenic and an
therefore isodimorphous.

ARSIDOGEN. The name given by L. Gmelin (Handb. ix. 315), to
thetical compound AsH^2 (= Ar), analogous to amidogen, NH^2, formerl
by Laurent, Gerhardt, and Dumas, to exist in cacodyl and its derivatives
ing to this view, cacodyl was supposed to be the hydride of a compoun
analogous to ethylene, viz. $C^4ArH^3.H$; oxide of cacodyl = $C^4ArH^3.HO$;
sulphide = $C^4ArH^3.HS$, &c.

ARTHANITIN, or **CYCLAMIN,** a crystalline substance extracted b
(J. Chim. méd. vi. 417), from the roots of *Cyclamen Europæum* (*Arthanita*
—It is said also to exist in small quantity in the roots of the cowslip (*Prin*
of *Anagallis arvensis*, and *Limosella aquatica*.—It is prepared by digesting
roots of cyclamen with alcohol, evaporating the extract, and treating the re
with ether, then with cold water: the insoluble part constitutes arthani
purified by recrystallisation from alcohol, with the aid of animal charcoal
tallises in fine colourless needles, which are inodorous, but have a strongly
styptic taste. It is neutral to vegetable colours, dissolves in 500 pts. of wat
in alcohol. It is altered at the temperature of boiling water, becoming less
alcohol. Nitric acid transforms it into oxalic acid. Sulphuric acid commu
it a violet-red tint. Taken internally, arthanitin acts like a purgative, and
vomiting.

KE. According to Verdeil (Compt. rend. xli. 588), the green colour-
e artichoke (*Cynara scolymus*) and other composite plants, is a sub-
from chlorophyll, and is formed by the action of the air, water, and
e comminuted parts of the plants. The liquid, which has a fine green
th acetic acid a bulky green precipitate, which resembles indigo when
reated with aqueous alkalis, again forms solutions of a beautiful green

e yields, according to Richardson (Ann. Ch. Pharm. lxvii. Table),
e, 1·17 per cent. of ash; in the dry state, 6·2 per cent. In the roots,
s of the Jerusalem artichoke (*Helianthus tuberosus*) Way and Ogstor
c. Soc. vii. [2] 593) found in the fresh state, 1·79, 1·94, and 15·00 per
the same parts when dried, 12·2, 4·4, and 28·3 per cent. The con-
ash are given in the following table:

	Artichoke.	Jerusalem Artichoke.		
		Root.	Stem.	Leaves.
	24·0	55·9	38·4	6·8
	5·5		0·7	3·7
	9·6	3·3	20·3	40·1
	4·1	1·3	1·9	2·0
l (SO^3)	5·2	3·8	3·2	2·0
(CO^2)		11·8	25·4	24·3
id (P^2O^5)	36·2	16·7	3·0	0·6
	7·0	1·5	1·5	17·5
f iron		0·5	0·9	1·1
tassium		5·0		
dium	3·6		4·7	1·8
te of iron	4·8			

PUS INCISA. The fruit of this tree, the bread-fruit tree, which
nds of the East Indian Archipelago, contains 14 per cent. of starch,
nin, 19 gluten and woody fibre, and 63 water.

ULENTUM. The fresh tubers of this plant yield, according to
h (Chem. Soc. Qu. J. iii. 193), 1·65 per cent. ash, containing in
ts. soluble in water, and consisting of 45·1 K^2O; 8·1 NaCl; 3·8 SO^3;
38·7 pts. insoluble in water, consisting of 18·3 K^2O; 1·1 Fe^2O^3;
O^2.

CULATUM. The fresh plant contains a sharp milky juice, which pro-
on of the skin, but is so volatile and unstable that it is no longer present
. The dry root is said to contain 71 per cent. starch, together with
and vegetable mucus.

PHRAGMITES. The dry plant yields 4·7 per cent. of ash, which,
ulz-Fleeth (Pogg. Ann. lxxxiv. 80), contains in 100 pts.: 8·6 K^2O,
gO; 0·2 Fe^2O^3; 2·8 SO^3; 71·5 SiO^2; 6·6 CO^2; 2·0 P^2O^5; 0·4 NaCl.

IS. See Benzoin.

DA. *Gummi Asæ fœtidæ*, *Stinkasant*, *Teufelsdreck.*—A gum-resin
he root of the *Ferula Asafœtida*, an umbelliferous plant growing in
t, which is black on the outer surface, resembles a large parsnep. On
ersely, the asafœtida exudes in the form of a white juice, like cream, but
e air, it gradually becomes yellow and at last dark brown. It is very
composition; hence, those who collect it carefully defend it from the sun.
as an excessively strong smell, which grows weaker and weaker upon
e dram of the fresh fluid smells more than a hundred pounds of the
rought to us. The Persians are commonly obliged to hire ships on
arriage, as scarcely any one will receive it along with other commo-
infecting everything that comes near it.
et with, sometimes in small drops or tears, but more frequently in
with white streaks. Specific gravity 1·327. Its recently fractured
ittle colour, but quickly reddens on exposure to the air. It is friable
eratures, but softens at the heat of the hand. It dissolves in alcohol
dily than in water. It has an extremely disagreeable alliaceous
arp biting taste. It contains in 100 pts., according to Pelletier
i. 556), 65·0 of resin, 19·4 soluble gum, 11·2 bassorin, 3·6 volatile
alate of calcium. According to Johnston (Phil. Mag. Dec. 1838)
œtida, which may be extracted by alcohol, is of a light yellow colour,

when pure, but becomes purple on exposure to the sun. It contains
per cent. of carbon, 7·6 of hydrogen, and 22·2 of oxygen; no sulphur.
is used as a remedy in nervous and hysteric affections, as a deob
sometimes as an anthelmintic. It is said to be used also by some Asiati
condiment.

Oil of Asafœtida.—Asafœtida distilled with water yields about 3 pe
sulphuretted essential oil, to which its odour is due. This oil is neutral, b
between 135° and 140° C., and when left at rest, gives off a considera
of sulphydric acid. Hlasiwetz (Ann. Ch. Pharm. lxxi. 23) obtained fro
lysis, from 64·2 to 69·3 per cent. carbon, from 9·1 to 10·5 per cent. hydrog
to 25·5 per cent. sulphur, its composition varying with the time elaps
preparation. Hlasiwetz regards it as a variable mixture of the two
$C^{12}H^{22}S^{4}$ and $C^{12}H^{22}S$. When it is treated with oxide of silver, sulphu
is formed, and the liquid, if afterwards rectified, contains 65·6 per cent
and 24·8 S. On agitating it with strong solution of potash and hydrate
then rectifying, an oil is obtained having an odour of lavender or rosema
taining about 60·7 per cent. C, 9·5 N, and 29·85 S. An oil having the s
sition is obtained by passing sulphurous acid gas through the crude oil.

The alcoholic solution of oil of asafœtida forms with dichloride of plat
or brown precipitates varying in composition, according to the strength of
and the duration of the action, but all containing the same proportions of
hydrogen as the oil itself, viz. $C^{6}H^{11}$.

On mixing concentrated alcoholic solutions of oil of asafœtida and chlo
cury a white precipitate is formed, which is partly dissolved by boiling
the solution on cooling yields microscopic crystals containing $(C^{6}H^{11})$
$2(C^{6}H^{11})^{2}Cl^{4}.HgCl^{2}$. The portion of the precipitate insoluble in alcoh
when treated with potash, a proof that it contains mercurous chloride: i
to contain $C^{6}H^{11}S^{4}.HgS.2Hg^{2}Cl^{2}.2Hg^{2}S^{2}Cl^{2}$. Both these mercury-compo
treated with sulphocyanate of potassium, yield a volatile oil smelling
mustard, and like that oil, forming a crystalline compound with ammonia
however contain allyl, but probably the homologous radicle, $C^{6}H^{11}$. (
Hand. d. Chem. 2te Aufl. ii. 339.)

ASARIN or **ASARONE**, $C^{20}H^{26}O^{5}$.—This substance is contained in
asarabacca (*Asarum europæum*) and passes over in the crystalline form w
root is distilled with water. The crystals belong to the monoclinic or o
matic system, and resemble camphor in taste and odour. Asarone melts at 4
to boil at 280°, and may be sublimed in small quantity between two w
It is insoluble in water, but dissolves readily in alcohol, ether, and es
When it is boiled for some time with alcohol, the solution gradually turns
portion of the asarone is converted into an uncrystallisable, resinous, isome
tion, which does not distil with vapour of water, and decomposes at 300
acid converts asarone into oxalic acid. It is dissolved with red colour by
phuric acid, and reprecipitated by water. It is strongly attacked by chl
off hydrochloric acid, and yielding a thick oil whose composition approxi
formula $C^{20}H^{22}Cl^{4}O^{5}$. (Goertz, Pfaff's System d. Materia Medica, iv. 229
and Sell, Ann. Ch. Pharm. vi. 296; Schmidt, *ibid.* liii. 156.)

ASARITE. A camphor-like substance found, together with asarone, i
Asarum europuæm, and resembling that substance in many respects, but di
it in appearance, in not decomposing so readily when sublimed, but chiefly i
point which is 70° C. whereas that of asarone is 40°. It is obtained by
alcohol the impure crystals of asarone as they are obtained by distilling t
water, precipitating by alcohol, and collecting the small silky crystals
about in the liquid. Gräger, who obtained this substance at first, regar
distinct body, but was afterwards disposed to regard it as identical with
difference in the melting point is, however, too great to be accounted for
observation. Blanchet and Sell suppose it to be the solid part of asu
asarone a product of the decomposition of that oil.

ASARUM-OIL. A volatile oil existing in small quantity (about $\frac{1}{150}$
of *Asarum europæum*, and passing over, together with asarone, when the ro
with water. It may be separated from the asarone by treating the oily p
distillate with a small quantity of alcohol. Two layers then form, the
an alcoholic solution of asarone, containing a little of the oil; the lower,
small quantities of asarone and alcohol in the oil. On distilling this lowe
hydrate of lime, and leaving the distillate to stand for some time, the a
rates out, and the remaining oil may be dehydrated by chloride of cal

h and viscid, smells like valerian oil, has a sharp burning taste, is lighter
paringly soluble in water, but easily soluble in alcohol, ether, and in oils
volatile. Blanchet and Sell (Ann. Ch. Pharm. vi. 296) deduce from
(74·4 C, and 9·7 H) the formula C^8H^9O, which does not agree very
the formula $C^{10}H^{13}O^2$, is more in accordance with the analysis. As, how-
loubtless still contained asarone, it is useless to attempt to determine its
tly till further experiments are made. It appears, however, to contain
and hydrogen than asarone, which therefore may have been formed from
n.

OS, or **ASBESTUS.** (*ἄσβεστος*, indestructible.)—A mineralogical term
o denote a peculiar form assumed by several minerals, than to designate
r species. It is, in fact, applied to several varieties of amphibolic and
als, such as *actinolite*, *tremolite*, *anthophyllite*, &c. which occur in long
tals, placed side by side in a parallel position, thus producing a fibrous
conditions may be fulfilled in various degeees, and there are accordingly
of asbestos. Those varieties whose fibres are very delicately and regu-
l, are called *flexible asbestos*, or *amianth* (a Greek term, signifying *unpol-*
individual crystals are easily separated from each other, are very
lastic, and have a white or greenish colour, with a fine silky lustre. A
this mineral fuses readily into a white enamel; but in the mass, it is
sisting ordinary flame, so that when woven it produces a fire-proof cloth.
utiful specimens are found in the Tarantaise in Savoy, and in Corsica,
rs very abundantly. It is also found near Barège in the Pyrenees, in
d on the St. Gothard; at St. Neverne in Cornwall; at Portsoy in Scotland;
t Glenelg, Inverness-shire; and near Durham. Those varieties in which
are coarser, with scarcely any flexibility, are called *common asbestos.*
so three other varieties, called *mountain leather*, *mountain cork*, and
od, which differ from common asbestos by the fibres interlacing each

sbestos occurs in masses of fibres of a dull greenish colour, and of a
arly lustre. Fragments splintery. It is scarcely flexible, and much
amianthus. It is slightly unctuous to the touch. Specific gravity 2·7.
fficulty into a greyish-black scoria. It is more abundant than amianthus,
usually in serpentine, as at Portsoy in the Isle of Anglesea, and at the
nwall. It was found in the limestone of Glentilt, by Dr. M'Culloch, in a
ut soon hardened by exposure to air.

Leather consists, not of parallel fibres like the preceding, but inter-
nterlaced so as to become tough. When in very thin pieces, it is called
er. Its colour is yellowish-white, and its touch meagre. It is found at
, in Lanarkshire. Its specific gravity is uncertain.

Cork, or *Elastic Asbestos*, is, like the preceding, of an interlaced fibrous
que; has a meagre feel and appearance, not unlike common cork, and
tance is somewhat elastic. It floats on water. Its colours are, white, grey,
-brown. It takes an impression from the nail; is very tough; cracks when
melts with difficulty before the blowpipe. Specific gravity from 0·68

Wood.—Ligniform asbestos is usually massive, of a brown colour, and
of wood. Internal lustre glimmering. Soft, sectile, and tough; opaque;
; melts to a black slag. Specific gravity 2·0. It is found in the Tyrol;
nd in Scotland, at Glentilt, Portsoy, and Kildrumie.

ts manufactured cloth out of the fibres of flexible asbestos, for the pur-
upposed, of wrapping up the bodies of the dead when exposed on the
This cloth has also been made in modern times, the chief artifice
consist in the admixture of flax and a liberal use of oil, both which
e afterwards consumed by exposing the cloth for a certain time to a
loves are made of it for holding red-hot crucibles, &c. The cloth of
en soiled, is restored to its primitive whiteness by heating in the fire.
irs the flexibility of asbestos in a slight degree.—U.

N. See Cobalt, Earthy.

NE. A nitrogenous substance contained, according to Braconnot (Ann.
] xxxi. 37), in soot (ἀσβολη). It is extracted by boiling the soot with
rating, redissolving in water, adding hydrochloric acid to the solution,
pitchy precipitate with cold water, then boiling it with water, filtering
evaporating again, and treating with boiling water till no deposit forms
The liquid then yields by evaporation a kind of varnish, partially soluble

in alcohol; and on treating the residue with ether and evaporating, asboline remain the form of a yellow, very acrid, bitter, volatile oil, which is lighter than water, bo with flame, and yields an ammoniacal product by distillation. Asboline dissolve nitric acid, yielding picric and oxalic acids. Its aqueous solution is coloured deep by alkalis, forms an orange-coloured precipitate with acetate of lead, reduces nitrat silver, and is precipitated by infusion of galls.

ASCLEPIADIN. A bitter emetic principle, contained in the *Asclepias* vi *toxicum.* It is insoluble in water, alcohol, and alcoholic ether. It appears no contain nitrogen. (Fenelle, J. Pharm. [2] xi. 565.)

ASCLEPIONE. $C^{20}H^{34}O^{3}$.—When the white milky juice of *Asclepias syriac* heated, the albumin contained in it coagulates, and on treating the coagulum ether, and evaporating, asclepione is deposited in finely radiated or cauliflower- groups of crystals. It is tasteless, inodorous, quite insoluble in water and alcohol, dissolves readily in ether, less easily in oil of turpentine, naphtha, and strong ac acid. It melts at 104° C., and then remains amorphous. At a higher temperatur decomposes, giving off the odour of burnt caoutchouc. It is not attacked by str boiling potash. (List, Ann. Ch. Pharm. lxix. 125.)

ASH OF ORGANIC BODIES. When any part of an organised bo vegetable or animal, is burnt with free access of air, part of it is resolved into vola compounds, chiefly water, carbonic anhydride, and free nitrogen, while the other, generally the smaller portion, is left as incombustible residue or ash. This resi may contain the following elements: —

Basic.	*Acid.*
Potassium	Chlorine
Sodium	Bromine
Calcium	Iodine
Barium	Phosphorus (as phosphoric acid)
Iron	Sulphur (chiefly as sulphuric acid)
Magnesium	Silicon (as silicic acid)
Manganese	Carbon (as carbonic acid, and occasionally as cyanogen).
Aluminium	
Copper	
Zinc	
(Lead, nickel, cobalt, tin)?	

These substances are the so-called inorganic or mineral constituents of the ve table or animal structure; they are essential to its existence, and are associated w the organic matter in certain definite forms, not necessarily the same as those wh they assume in the ash. It must be remembered, however, that the distinct between the organic and inorganic elements of an organised body is by no me absolute: for the carbon and oxygen, which are never absent from the ash, belo essentially to the organic structure of the body. Perhaps the best distinction betw the organic and inorganic constituents of a plant or animal body is, that the form viz. the carbon, hydrogen, oxygen, and nitrogen, are derived, in great part at le from the air, whereas the latter are derived exclusively from the soil.

The inorganic constituents above enumerated are not all of equal importance to existence of organised structures, or of equally frequent occurrence. Potassiu sodium, calcium, magnesium, and iron, associated with phosphoric acid, sulphuric ac carbonic acid, silicic acid, and chlorine, are almost always present, in greater lesser quantity, in the ashes of organised bodies, whether vegetable or anim fluoride of calcium, in very small quantity, appears also to be an almost invariable c stituent; and manganese, also in small quantity, is of frequent occurrence; the oth elements are of rare or doubtful occurrence.

The mineral constituents of plants and animals vary greatly in amount, as well in composition. In *bone*, the inorganic matter constitutes from $\frac{1}{3}$ to $\frac{3}{4}$ of the ent mass, the amount in individual cases depending upon the age and species of animal; in the higher classes of animals, the bone-ash consists mainly of phospha of calcium, with a smaller quantity of carbonate; in the lower classes, the prop tions of these constituents are reversed. Phosphate of calcium occurs also in ashes of the *albuminous principles*, both of plants and animals, and is especially abu dant in the *seeds* of cereal and leguminous plants; phosphate of magnesiu is abundant in the ash of wheat-grain. The alkaline chlorides are ve widely diffused throughout the bodies of plants and animals; chloride of sodiu is invariably present in the fluids of the animal body and in the juices of plan Alkaline carbonates are always present in the *blood*, and appear to be essent to the solution of the albuminous principles. Carbonate of potassium forms

of *wood-ash*. Silica is scarcely ever absent from the ashes of organised
e ashes of *equisetaceous plants* contain 97 per cent. of silica. The hard
athing of the stems of *grasses* consists of silicate of potassium. The
e lowest classes of animals, *infusoria*, &c., consist mainly of silica, which
deposited in their organs, that neither decomposition nor incineration can
form: hence it is that deposits of infusoria are so often discovered. In
nd juices of the higher classes of animals, silica occurs only as an inci-
ituent, though it is seldom altogether absent. According to Gorup-
nn. Ch. Pharm. lxvi. 342), it forms an integral constituent of *feathers* and

occurs to the amount of about 1 per cent. in all the albuminoïdal sub-
is converted during incineration into sulphuric acid, which is found in
kaline sulphate, sometimes however more or less reduced to sulphide by
the carbon at a high temperature. The juices of the animal body and of
ontain small quantities of alkaline sulphates and sulphate of calcium.
lways present in vegetable and animal tissues and fluids, and is found in
esquioxide, either free or as basic phosphate.
has been found in considerable quantity in the juice of plants which ex-
reaction, *e.g.* in *Lycopodium chamæcyparissus*, *L. clavatum*, and *L. den-*
alm-Horstmar, J. pr. Chem. xl. 302; Aderholdt, Ann. Ch. Pharm.
Solms-Laubach, *ibid.* c. 297). In most other plants, alumina is alto-
t, any small quantities that may be found in the ash, generally arising
y in the reagents, especially in the caustic potash or soda, or from want
in cleansing the leaves, roots, or other parts under examination, from
ticles of soil.
metals above-mentioned as occasional constituents of ashes, occur only
l quantity, their presence being mostly, perhaps, due to some peculiarity
ion of the plant or animal in which they are found. A peculiar kind of
calaminaris) with yellow flowers, was found by A. Braun (Pogg. Ann.
contain zinc, which metal was likewise found in the soil, its presence
termining the production of the peculiar variety of the plant. The ash of
d of *Limulus cyclops* was found by Genth (Pogg. Ann. xcv. 60) to contain
per cent. of oxide of copper. The occurrence of titanic acid in
is mentioned by Städeler (Wöhler's prakt. Chem. Uebungen, 1853
aryta by Scheele (in 1788), and more recently by Eckard (Ann. Ch.
4), and by Forchhammer (Pogg. Ann. xcv. 60; Jahresber f. Chem.
). On the occurrence of copper and other metals in plant-ashes, see also
1847—8, p. 874; 1849, p. 430; 1852, p. 702; 1853, p. 604.
neral constituents of plants are all derived from the soil and vary greatly
unt and in composition, it will be easily understood that the examina-
-ashes is of great importance with reference to agriculture. A plant will
soil deficient in the mineral substances which it requires; if phos-
s deficient, wheat and other cereal grasses cannot form their seed in its
unt; if there is a deficiency of silica, the straw will be weak. Some
e abundance of alkali, others of lime, &c. The examination of the ash
particular mineral substances the plant requires, and consequently what
ust be supplied to it artificially in the form of manure, if they are not
ined in the soil.
roceed to describe the preparation and analysis of ashes.

tion of the Ash.—The substance to be incinerated must in the first
fully freed from extraneous matter. Herbs, roots, and barks, which are
ble to be contaminated with adhering mould, clay, or sand, must first
rom the grosser impurities by scraping, or otherwise, and then washed
tly moistened sponge to remove the fine dust; washing with large quanti-
is objectionable, as it may remove some of the soluble salts. Seeds are
by pouring distilled water upon them in a glass jar, stirring for a little
rod, and then pouring the whole on a coarse sieve, which allows the fine
rough, but retains the seeds. After repeating this treatment two or three
eeds may be further cleansed by rubbing them between a linen cloth.
tances are less liable to contamination with mechanical impurities:
ation is often facilitated by exhausting them with water, and incinerat-
ly the aqueous extract and the residue. The quantity of material
hould be such as to yield from 4 to 6 grammes of ash. Of seeds, roots, barks,
hich are for the most part rich in mineral constituents, from 100 to 200
the dried substance is generally sufficient; of wood, two or three times
y must be taken; of animal substances containing a large amount of

water, it is often necessary to incinerate a much larger quantity. The substance should, previous to incineration, be carefully dried and somewhat comminuted; seeds, however, if not very large, are best incinerated without comminution.

The incineration must be conducted with great care, as the constitution of the ash is often materially affected by the manner in which it is performed. The chlorides of potassium and sodium, though fixed at comparatively low degrees of heat, volatilise perceptibly at the high temperature sometimes attained during the incineration, especially in a current of air; this is still further the case with iodides. Moreover, by the joint action of silica and charcoal, phosphates may be decomposed and phosphorus volatilised; sulphates also reduced to sulphides, or sulphuric acid driven off. And even when no actual loss takes place, different modes of incineration may give rise to considerable differences in the composition of the ash. Carbonates in an ash generally result from the combustion of salts of organic acids existing in the substance burned; they may, however, be introduced in other ways. If tribasic phosphate of sodium be ignited in presence of a large quantity of organic matter, sugar, for example, till the organic matter is charred, and the mass be then lixiviated with water, a solution of carbonate of sodium is obtained, and the residue, after the charcoal has been completely burned away, consists of pyrophosphate of sodium, the carbonic acid produced by the combustion of the organic matter having decomposed the tribasic phosphate, taken away 1 at. of the base, and converted it into carbonate. If, on the other hand, the mass be at once completely incinerated without lixiviation of the charcoal, nothing but tribasic phosphate will be obtained. In all cases then, in which the arrangement of the mineral constituents of an organised structure is to be inferred from the composition of the ash, great care must be taken to guard against or allow for any such modifications as that just noticed. In the examination of plant-ashes for agricultural purposes, such questions are indeed of minor importance, the chief object of the investigation being to determine the ultimate constituents of the ash; but in physiological inquiries, the actual arrangement of the mineral constituents in the living structure is often a point of great importance.

The difficulty of incinerating an organic substance is greatly increased when the ash is easily fusible, the decompositions just considered being then most likely to occur. Leaves, herbaceous stems, roots, bark, &c., which chiefly contain infusible salts of the alkaline earths, are comparatively easy to burn; but seeds, and many animal substances, such as dried blood, which contain large quantities of alkaline salts, are very troublesome, and require great care in regulating the temperature.

The method of incineration originally practised, especially for the preparation of plant-ashes, consisted in burning the dried substance in a Cornish or Hessian crucible, laid obliquely in the fire, and kept at a moderate red heat. The carbon then burns away with greater facility, the looser the texture of the charred mass, and the less its position and form are altered by movement and stirring. The objections to this method are that it often gives incorrect results regarding the amount of phosphoric acid, carbonic acid, and chlorine, inasmuch as chlorides are decomposed by the action of acid phosphates in presence of water, and at very high temperatures, phosphorus may be volatilised by the action of charcoal on acid phosphates. Extraneous matters may also be introduced into the ash by the action of phosphates in a state of fusion on the crucible.

A much better method is that recommended by Erdmann, which consists in incinerating the plant or animal substance in a muffle built into the mouth of a furnace in such a manner that the heat may play upon it chiefly from the top. The incineration goes on most favourably at a distance of 3 or 4 inches from the front aperture of the muffle, and at a low red heat not visible by daylight. At this temperature, there is no danger either of the volatilisation of chlorides or of the fusion of phosphates. If the muffle be kept loosely closed by a clay stopper, sufficient air will enter to produce, in the course of twelve hours, a quantity of ash free from charcoal sufficient for an analysis. A convenient mode of proceeding is first to char the substance in a platinum or porcelain dish, and then heat the charred residue in the muffle in the manner just described; the charcoal then burns away with slight incandescence. The ash may afterwards be weighed in the dish.

Messrs. Lawes and Gilbert use cast-iron muffles 18 inches long, 3½ inches high, and 5 inches wide at the bottom. The muffle, which has a flange at the fore part, fits exactly into an orifice in a cast-iron furnace front; and a 1½ inch pipe proceeding from the farther end of the muffle, passes through the cast-iron furnace back, and serves to carry away the evolved gases. The muffle rests on a brick in the furnace, to lessen bottom heat and thus prevent fusion, the fuel being heaped up at the sides and top, chiefly the latter. The substance is burnt in large platinum sheets or dishes, the latter 10 inches long, 4 to 5 inches wide, and 1½ inch deep. By this arrangement, the access of ash from the fire is entirely avoided; the ash is burnt by surface, not by

eat; the draught of air is free; and the incineration may be accomplished at
v temperature.*
by far the best mode of incineration yet devised; nevertheless it is occa-
tended with slight loss of sulphur, phosphorus, chlorine, iodine, &c. To ob-
e losses, it has been proposed to mix the substance to be incinerated with lime,
other strong bases capable of retaining the acids. **Wackenroder** adds for
ose, acetate or carbonate of calcium, or quick lime; **Strecker** proposes to
he dried and charred substance with such a quantity of baryta-water, that the
incineration, may contain about half its weight of baryta. The moistened
s then dried and burnt in the muffle at as low a temperature as possible. To
s which produce ashes containing much carbonic and silicic acids, **Way** and
add for the same purpose, nitrate of barium; **Slater** adds peroxide of barium;
nitrate of ammonium; and **Will**, mercuric oxide; but all these admixtures
led with peculiar inconveniences, which stand in the way of their genera
n.

e adds a weighed quantity of carbonate of sodium, chars the substance in a
nd burns away the charcoal by directing a stream of oxygen upon it through
re in the lid. This method effects a complete and rapid combustion of the
but the high temperature produced often causes the ash to fuse, and then the
s attacked. Crucibles of stone-ware (*Steingut*) withstand the action better
e of porcelain.

e methods of **Mitscherlich** and **Hlasiwetz**, see Handw. d. Chem. 2te Aufl.
or the latter also, Ann. Ch. Pharm. xcvii. 244.]

sis of the Ash.—Of the various methods which have been given for the
of ashes, the simplest and most generally applicable is that of Professor
ndw. d. Chem. 2te Aufl. ii. 361; Conington's Handbook of Chemical Analysis,
The ash prepared in the muffle at the lowest possible temperature, is tritu-
uniform powder, and preserved in a stoppered bottle. One portion of it is
etermine the carbonic acid by one of the methods given under ALKALIMETRY.
A second is treated with dilute nitric acid, and the filtrate is used for deter-
e chlorine by precipitation with nitrate of silver; while a third portion (4 or 5
is used for determining the silica and the other constituents. For this last
he ash is treated with hydrochloric acid; the silica separated by complete
on to dryness, and digestion of the residue with water containing hydro-
id (see SILICA); and the quantity of the filtrate, together with the washings, is
d, either by weight or by measure.

portion of this filtrate, of known weight or volume, the sulphuric acid is
ed by precipitation with chloride of barium; in a second, the lime, magnesia,
de of iron (alumina, if present), and the phosphoric acid; in a third, the

Magnesia, Ferric Oxide, Phosphoric Acid.—If, as in the ashes of seeds and of
mal substances, all the bases, or the greater part of them, are present as
es, the liquid is first supersaturated with ammonia (or mixed with acetate of
then with acetic acid, and the undissolved ferric phosphate, $Fe^4O^3.cP^2O^5$, is
and weighed (together with phosphate of aluminium, if present, which may
s be separated by potash). The lime is next precipitated by oxalic acid,
of the phosphoric acid and all the magnesia by ammonia, and the rest of the
ic acid by a magnesium-salt. In ashes containing a smaller proportion of
ic acid, part or the whole of the magnesia remains in solution after this treat-
his portion is determined by precipitation with phosphate of sodium, or (if
e is to be afterwards used for the determination of the alkalis) with phosphate
nium. If manganese is likewise present (as a manganous salt), the ferric
e is first precipitated as above; the liquid filtered from the precipitate is
th a known volume of a standard solution of ferric chloride made as neutral
le; the whole is heated to boiling; the precipitate thoroughly washed with
r and dried; and from its weight, that of the (anhydrous) phosphoric acid is
deducting the weight of the ferric oxide added†; to this quantity of phos-
id, must be added that which was previously determined as ferric phosphate
sphate of aluminum). In the filtrate, which contains manganese, calcium,
nesium, these metals are determined by the usual methods, the manganese
cipitated as peroxide by hypochlorite of sodium, the precipitate collected after
ur hours, then ignited or weighed as manganoso-manganic oxide (Mn^3O^4).
.—The ash, dissolved in hydrochloric acid, not in great excess, is mixed with

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e above description, the Editor is indebted to the kindness of Dr. Gilbert.
nount of phosphoric acid in this precipitate might be determined directly by dissolving in
ic acid, adding sufficient tartaric acid to prevent precipitation of iron and alumina by alkalis,
g excess of ammonia, and precipitating by a magnesium-salt.

oxalic acid, then with excess of ammonia, and if magnesia is still in solution with phosphate of ammonium.* The precipitate is washed with ammoniacal water; the filtrate is evaporated a little to expel the excess of ammonia, and mixed while still hot with acetate of lead; the liquid is again filtered, and the excess of lead removed by ammonia and carbonate of ammonium; the filtrate from this precipitate, together with wash-water, is evaporated with addition of sal-ammoniac; and the ammoniacal salts are expelled by gentle ignition. The residue, which contains nothing but the chlorides of potassium and sodium, is then weighed, and the relative quantities of the two chlorides are determined, either by precipitating the potassium with dichloride of platinum, or determining the amount of chlorine by precipitation with nitrate of silver. (See ANALYSIS, INDIRECT, p. 220.)

Knop and **Arendt** (Chem. Centralbl. 1857, 169), determine the phosphoric acid in ashes by adding *uranic acetate* to the solution, acidulated with acetic acid as above, whereby a precipitate of ammonio-uranic phosphate is produced, which, when ignited with addition of a few drops of nitric acid, leaves uranic phosphate, containing $2Ur^2O^3.P^2O^5$. (For the details of the method, see PHOSPHORIC ACID, under PHOSPHORUS.)

For other methods of ash-analysis, see **Fresenius** and **Will**, Ann. Ch. Pharm. l. 363; **Erdmann**, J. pr. Chem. xxxviii. 20; **H. Rose**, Pogg. Ann. lxxx. 94, and Handb. d. Analyt. Chem. ii. 766; **Mitscherlich**, J. pr. Chem. xxxv. 231; **Wackenroder**, Arch. Pharm. [2] liii. 1; **Städeler**, Prakt. Uebungen in der Chem. Anal. von Wöhler, 1853, 172; **Wittstein**, Pharm. Centralbl. 1853, 761. Also for a description of all these methods, Handw. d. Chem. 2te Aufl. ii. 353.

For the composition of the ash of individual plants, see the names of the plants in this dictionary. Extensive tables of the composition of plant-ashes are given in the first five volumes of Liebig and Kopp's *Jahresbericht für Chemie*, 1847 to 1852. The new edition of Ure's *Dictionary of Arts, Manufactures, and Mines* (i. 212), also contains a table showing the average composition of the ash of some of the most useful agricultural plants.

ASH, VOLCANIC. This name is applied to the pulverulent portion of the matter thrown out by volcanos. The ash emitted by different volcanos, by the same volcano at different times, and even at different stages of the same eruption, exhibits great differences of structure and composition. It is sometimes dark-coloured or even black, and composed of earthy or soft particles, sometimes grey or white, and finely divided. In the eruption of Vesuvius, A.D. 79, which overwhelmed Pompeii and Herculaneum, the ash was so fine and dry that it took exact casts of objects buried in it. It is this finely divided matter to which the term **ash** is especially applied, the coarser varieties being generally denominated **volcanic sand**; it sometimes rises to considerable heights, and is then carried by the wind to great distances. In the eruption of Coseguina, on the Bay of Conchagua, in Guatemala (1835), some of the ash fell at Kingston in Jamaica, at a distance of 700 miles.

Volcanic ash, when examined by the microscope, appears to be composed of fragments of lava, slag, mica, felspar, magnetic iron ore, augite, pumice, olivine, &c. It is therefore a mechanical mixture of minerals and rocks abraded by trituration against each other. In the ash thrown out by Vesuvius on the 22nd of October 1822, Vauquelin found 28 pts. silica, 8·0 alumina, 18 gypsum, 20·88 iron pyrites, 2·6 lime, and 1 carbon, together with 41·42 pts. sulphate of copper, sulphate of ammonium, chlorides, and sulphur. In the ash emitted from the crater of the Soufrière in Guadeloupe, in 1797, **Dufrénoy** (Ann. Ch. Phys. [2] lxvii. 251) found 2 per cent. of alum, potash, and gypsum, 8·84 water, 32·61 pts. of matter attacked by acids (which he regarded as labrador), and 56·23 pts. not attacked by acids (regarded as glassy felspar). In the ash thrown out by the same crater in the year 1836, Dufrénoy found 50·88 pts. of matter insoluble in acids, 33·72 pts. soluble in acids, 6·93 water and 0·62 sulphur (loss 1·85 per cent.)

The following table contains the results of a few more recent analyses: *a*, *b*, ash from the above-mentioned eruption of Coseguina (**Dufrénoy** and **Élie de Beaumont**, Ann. Ch. Phys. [2] lxviii. 266); this ash contained 18 pts. of matter decomposible by hydrochloric acid (*a*), and 82 pts. unattacked by that acid (*b*). *c*, Ash from Gunnung-Gurtur, in Java; eruption of January 4th, 1843 (**Mayer**, Leonhard and Bronn's Jahrb. d. Miner 1853, 463). *d*, Ash from the same volcano; eruption of November 25th, 1843. Of this ash, water dissolved 0·3 per cent. consisting of lime and magnesia-salts (**Schweitzer**, J. pr. Chem. lxv. 194). *e*, So-called *ferric* ashes, and *f*, so-called *ferrous* ashes from Etna (**Sartorius von Waltershausen**, "Vulcanishe Gesteine," Göttingen, 1853, 172). *g*. Ash from the eruption of Hecla in 1846 (**Genth**, *ibid.* 176).

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* For other methods of separating magnesia from the alkalis, see MAGNESIUM.

	a	*b*	*c*	*d*	*e*	*f*	*g*
. . . .	51·7	64·3	34·2	51·6	48·7	51·3	56·9
. . .	15·2	21·1	37·5	21·9	17·9	18·4	14·2
xide . . .	13·0	—	18·2	—	12·7	—	—
oxide . .	—	—	6·7	10·8	—	11·7	13·9
. . . .	11·1	1·4	0·7	9·3	5·5	7·5	6·2
a . . .	—	0·7	—	3·3	2·5	4·3	4·0
. . . .	6·2	9·6	—	2·9	4·5	4·6	2·3
. . . .	—	—	—	0·5	2·0	1·6	2·6
nd loss . .	2·8	3·4	1·0	0·6	6·6	0·5	—
oluble in water	—	—	1·7	0·3	—	2·7	—
	100·0	100·5	100·0	101·2	101·4	102·6	100·1

ARAGINE. $C^4H^8N^2O^3$, or $C^8H^8N^2O^6$. *Altheine, Asparamide.* (Gm. x. his substance was discovered in 1805 by Vauquelin and Robiquet (Ann. rii. 88). It exists ready formed in many plants, viz. in common asparagus *us officinalis*), in the marsh-mallow (*Althaea off.*), in comfrey (*Symphytum* potatoes, in chestnuts, in the leaves of the deadly nightshade (*Atropa Bella-* in liquorice-root, in the root of *Robinia pseudacacia*, in *Convallaria majalis*, *multiflora*, in the milky juice of the lettuce, in the tubers of the dahlia, and oung shoots of vetches, peas, beans, and several other leguminous plants grown ark. According to Piria (Ann. Ch. Phys. [3] xxii. 160), the young shoots of nts, when formed in the light, contain just as much asparagine as when they n in the dark; but the asparagine disappears as the plant arrives at the flower- . On the other hand, Dessaignes and Chautard (J. Pharm. [3] xiii. d likewise Pasteur (Ann. Ch. Phys. [3], lxxxi. 70), find that vetches growing are free from asparagine.

ration.—The juice obtained from the young shoots of *asparagus*, filtered and ed to a syrup, deposits after standing for some days, crystals of asparagine, ay be purified by recrystallisation from water. As the mucus of the plant the crystallisation, it is best to leave the shoots to ferment for a few days in place, and then bruise and press them, with addition of water; by this treat- e mucus is decomposed. In a similar manner, asparagine may be obtained rsh-mallow roots, and from the young shoots of vetches, &c. grown in the o obtain asparagine from liquorice-root, the root is cut into pieces and ex- with water; the liquid boiled to precipitate the albumin, then mixed with id to separate the glycyrrhizin contained in the root, and afterwards with f lead, which throws down phosphate and malate of lead, together with brown matter; and the excess of lead is removed by sulphydric acid. The liquid evaporated to a small bulk, deposits crystals of asparagine after a few

agine forms hard brittle crystals, $C^4H^8N^2O^3.H^2O$, belonging to the trimetric The ordinary form is a right rhombic prism, $\infty P . oP . m\breve{P}\infty . \infty\bar{P}\infty$, with ihedral faces $\frac{P}{2}$. Inclination of the faces, $\infty P : \infty P = 129° 37'$; $\frac{P}{2} : oP =$; $m\breve{P}\infty : oP = 120° 46'$. Specific gravity 1·519 at 14° C. The crystals are s, have but a slight taste, and are permanent in the air. They give off water llisation at 100° C. They dissolve in 11 pts. of cold, and 4·44 pts. of boiling he solution has a slight acid reaction. Asparagine dissolves also in acids and . It is insoluble in cold absolute alcohol, and nearly insoluble in that liquid r temperatures; insoluble also in ether and in oils, whether fat or volatile.

agine dissolved in water and in alkalis, deflects the plane of polarisation of a ght to the left; but when dissolved in acids, it deflects the plane of polarisa- he right. The specific rotatory power of an acid solution is + 35°, and of an cal solution, $-11° 18'$.

agine heated with strong acids or alkalis, is resolved into aspartic acid and :

$$C^4H^8N^2O^3 + H^2O = C^4H^7NO^4 + NH^3.$$

tals subjected to dry distillation also give off ammonia, and leave aspartic acid. ne dissolved in cold nitric acid, yields aspartic acid and nitrate of ammonium. n subjected to the action of nitrous acid, as when nitric oxide gas is passed a solution of asparagine in pure and moderately strong nitric acid, it is con nto malic acid, with evolution of nitrogen:

$$C^4H^8N^2O^3 + N^2O^3 = C^4H^6O^5 + N^4 + H^2O$$

The solution of pure asparagine-crystals may be kept unaltered; but if the crystals are coloured, their solution soon passes into a state of fermentation, and the whole of the asparagine is converted into succinate of ammonium:

$$C^4H^8N^2O^3 + H^2O + H^2 = C^4H^4(NH^4)^2O^4.$$

The hydrogen is derived from the fermenting matter. A solution of perfectly pure asparagine experiences the same change when mixed with a small quantity of the juice expressed from the young shoots of vetches (Piria). Asparagine ferments also under the influence of casein, and is converted first into aspartate of ammonium, afterwards into succinate.

Asparagine forms definite compounds with acids. The *hydrochlorate*, $C^4H^8N^2O^3.HCl$, is obtained in large crystals either by dissolving 1 at. asparagine in 1 at. hydrochloric acid, evaporating at a gentle heat, and adding alcohol; or by passing dry hydrochloric acid gas over finely pounded crystals of asparagine, exposing the resulting compound to the air till it no longer gives off acid vapours, then dissolving in hot water, and leaving the solution to cool.

Asparagine also forms salts in which 1 at. of its hydrogen is replaced by a metal: thus the *copper-salt* is $(C^4H^7N^2O^3)^2Cu$. These salts are obtained by mixing a solution of asparagine with the corresponding oxides. Asparagine also unites with chloride of mercury and nitrate of silver.

Asparagine has the same composition as malamide, $N^2(H^4.C^4\overset{\prime\prime}{H}{}^4O^3)$, and its conversion into malic acid by the action of nitrous acid, suggests the idea that it may be really the amide of that acid. According to Demondesir, however (Compt. rend. xxxiii. 227), and Pasteur (Ann. Ch. Phys. [3] xxxviii. 437) the amide obtained by the action of ammonia on malic ether, differs from asparagine in crystalline form and in other properties.

ASPARAGOLITE. An old name of the variety of apatite which has the green colour of asparagus.

ASPARAGUS OFFICINALIS. The ashes of wild and cultivated asparagus, and of the young heads of the cultivated plant, have been analysed by T. J. Herapath (Chem. Soc. Qu. J. ii. 9). 100 parts of the fresh wild plant yielded 2·42 pts. of ash; 100 pts. of same dried, 6·07 per cent. ash. The cultivated plant yielded in the fresh state 1·53, and in the dry state 6·07 per cent. ash. The young heads in a state fit for the table gave 0·81 per cent. and 11·24 per cent. ash. The constituents of the several ashes are as follows:—

Soluble in water:		Wild.	Cultivated.	Young Heads.
Anhydrous.	Carbonic acid	4·86	14·27	4·01
	Sulphuric acid	7·77	3·56	31·08
	Phosphoric acid	trace	2·10	
	Potash	15·81	32·74	32·63
	Soda	2·72	—	
	Chloride of sodium	20·51	trace	10·06
	Chloride of potassium	—	13·06	
Insoluble:				
	Carbonate of calcium	21·43	14·61	6·96
	Carbonate of magnesium	2·62	—	—
	Basic *c*-phosphate of calcium	21·67	16·21	14·05
	Basic ferric *c*-phosphate	1·70	0·46	0·21
	Silica	0·85	2·97	1·00
	Sulphate of calcium	trace	trace	trace
	Basic phosphate of magnesium	trace	trace	trace
		99·94	99·98	100·00
	Soluble in water (per cent.)	51·67	57·64	7·78
	Insoluble „ „	48·27	42·34	22·22

ASPARAMIDE. Syn. with ASPARAGINE.

ASPARAMIC ACID. Syn. with ASPARTIC ACID.

ASPARTIC ACID. $C^4H^7NO^4$, or $C^8H^7NO^8$. (Plisson, Ann. Ch. Phys. xxxv. 175, xl. 303.—Plisson and O. Henry, *ibid.* xlv. 315.—Boutron-Chautard and Pelouze, *ibid.* lii. 90.—Liebig, Pogg. xxxi. 232, Ann. Ch. Pharm. xxvi. 125, 161.—Piria, Ann. Ch. Phys. [3] xxii. 160.—Dessaignes, Compt. rend. xxx. 329; xxxi. 342; Ann. Ch. Pharm. lxxxiii. 83.—Pasteur, Ann. Ch. Phys. [3] xxxiv. 30; Ann. Ch.

xxii. 324.—Gm. x. 230; Gerh. i. 812.)—This acid, which is isomeric, if not
vith malamic acid, $O\left\{\begin{matrix}N.(H^2.C^4H^4O^3)\\H\end{matrix}\right.$, is obtained either by the decomposi-
aragine, chiefly under the influence of acids or alkalis, or by the action of
e acid malate, maleate, or fumarate of ammonium. The acids obtained by
processes are identical in composition, but differ in their relations to pola-
the former being optically active, the latter inactive.

re *active aspartic acid*, asparagine is boiled: 1. With water and oxide
long as ammonia continues to escape, the water being replaced as it
: the resulting aspartate of lead, after being purified by boiling with
alcohol, is decomposed by sulphydric acid, and the filtered solution is
till it crystallises (Plisson).—2. With baryta-water, the aspartate of
ng decomposed by sulphuric acid (Boutron and Pelouze).—3. With potash,
being afterwards evaporated to dryness with excess of hydrochloric acid, and
e of potassium dissolved out by water, which leaves the aspartic acid undis-
perfectly free from potash (Liebig).—4. With hydrochloric acid, for three
solution being then evaporated to dryness, and the residual chloride of
and hydochlorate of aspartic acid dissolved in a small quantity of water
neutralised with ammonia; the liquid on cooling deposits a considerable
f aspartic acid. (Dessaignes.)

spartic acid crystallises in very small thin, shining, rectangular plates, trun-
the angles; they belong to the trimetric system. Specific gravity 1·6613
C. It is much less soluble in water than asparagine, 1 pt. of it re-
4 pts. of cold water to dissolve it. In boiling water it dissolves more
t is nearly insoluble in alcohol. It dissolves readily in alkalis, and the
urn the plane of polarisation of a luminous ray to the left. It is also easily
the stronger acids, and the solutions thus formed turn the plane of polari-
he right. The specific rotatory power of the solution in hydrochloric acid
36′. (Pasteur.)

ve Aspartic Acid is obtained by heating acid malate of ammonium to
iling the residue for some hours with hydrochloric acid; dissolving the hydro-
aspartic acid, which crystallises from the liquid on cooling, in hot water, and
ting the solution with ammonia. Inactive aspartic acid then separates in
tals, belonging to the monoclinic system. Ordinary combination ∞P . oP.
clination of the faces, ∞P : ∞P in the plane of the oblique diagonal and
al axis = 128° 28′; oP : ∞P = 91° 30′; [P∞] : oP = 131° 25′. The crystals
d in stars, and sometimes take a lenticular form. Specific gravity 1·6632 at
The inactive acid is more soluble in water than the active acid, 1 part of it
in 208 pts. of water at 13·5° C. It dissolves very easily in hydrochloric
ric acid. The solutions have no action on polarised light. (Dessaignes,
)

acid is decomposed by heat, giving off ammonia and a faint empyreumatic
that evolved in the destructive distillation of animal substances. It is not
by boiling with hydrochloric acid or with dilute sulphuric acid, but when
h strong sulphuric acid, it decomposes, and sulphurous acid is given off. It is
posed by pure nitric acid, but if nitrous acid is also present, as when nitric
is passed through a solution of aspartic acid or nitric acid, the aspartic acid
ed into malic acid, with evolution of nitrogen gas:

$$\underbrace{2C^4H^7NO^4}_{\substack{\text{Aspartic}\\\text{acid.}}} + N^2O^3 = \underbrace{2C^4H^6O^5}_{\substack{\text{Malic}\\\text{acid.}}} + N^4 + H^2O$$

nds of Aspartic Acid with Acids.—Both the active and inactive varieties of
cid dissolve in the stronger acids, forming definite compounds, which by
n over the water-bath, or better by spontaneous evaporation, are obtained in
The compounds are active or inactive to polarised light, according as they
ed from the active or inactive acid.

ive hydrochlorate, $C^4N^7NO^4.ClH$, forms crystals belonging to the trimetric
hey are prisms with angles of about 90°, very much truncated on two
ateral edges, and terminated by faces inclined at an angle of about 115°, and
to an irregular tetrahedron. The crystals deliquesce in the air, the aspartic
set free. They are decomposed by solution in water, but the addition of a
of hydrochloric acid prevents the decomposition. Specific rotatory power
ution + 24·4°. The crystals are decomposed by heat, giving off water and
ric acid, and leaving fumarimide. The crystals of the *inactive hydrochlo-*
g to the monoclinic system, and differ altogether in appearance from those

of the active compound. Ordinary combination $\infty P . \infty P \infty . - P . oP . +$ ml
Inclination of the faces $oP : \infty P \infty = 119° 45'$; $\infty P \infty : \infty P = 123°$. The cry
are nearly unalterable in the air, only in summer losing their lustre and transpare
and becoming milk-white on the surface. They decompose when dissolved in w
but the inactive acid being more soluble than the active acid, is not precipitated
however, alcohol be added, an abundant precipitation takes place. The inactive
drochlorate is decomposed by heat like the active salt.

The *sulphate*, $C^4H^7NO^4.SO^4H^2$, is obtained by gradually adding aspartic acid to st
sulphuric acid heated to 50° or 60° C. in a wide glass tube, and leaving the tube c
for a few days; it then separates in large agglomerated prisms, which are lighter
the mother-liquor (Dessaignes). The *nitrate* is obtained, like the hydrochlora
beautiful crystals.

Aspartates.—Aspartic acid is monobasic, the formulæ of its normal salts b
$C^4H^6MNO^4$ and $C^8H^{12}M''N^2O^8$. It likewise forms basic salts, the composition of w
is not very clearly made out. The aspartates of the alkali-metals are soluble, and t
like broth. The active and inactive aspartates agree in composition, and in most of t
properties, differing only in solubility, crystalline form, and relation to polarised li

The *ammonium* and *potassium* salts are very soluble and difficult to crystallise.

The *sodium-salts*, $C^4H^6NaNO^4.H^2O$, are obtained by neutralising the acid w
caustic soda or its carbonate, and leaving the solutions to evaporate slowly; t
are perfectly neutral. The *active salt* crystallises in prismatic needles belonging
the right prismatic system, and terminated by faces of a tetrahedron inclined to
another at about 106°. The four faces of this tetrahedron are either present alone
are much more developed than those of the opposite tetrahedron, which, if equ
developed with the former, would constitute a rhombic pyramid; 1 part of this
dissolves in 1·12 pts. of water at 12·2 C. The specific rotatory power of the solu
is $-2° 23'$. The salt gives off its water of crystallisation at 160° C., turns yellow
gives off ammonia at 170°, and froths up considerably at higher temperatures. T
inactive sodium-salt crystallises in the monoclinic system, the ordinary combi
tion being $\infty P . \infty P \infty . oP . + P$. Inclination of the faces, $oP : \infty P \infty = 144°$
$\infty P : \infty P$, in the plane and of the oblique diagonal and principal axis $= 51°$
$+ P : + P = 112° 53'$. The salt often forms twin-crystals, with the face of ju
tion $\infty P \infty$. One pt. of the salt dissolves in 1·19 pts. of water at 12·5° C.

Normal barium-salt, $C^8H^{12}Ba''N^2O^8.4H^2O$.—The active salt crystallises in very sle
silky needles soluble in water, and giving off 14·4 per cent. water at 120° C. (D
saignes). The *inactive normal salt* forms an uncrystallisable gummy mass (Wol
The *basic* barium-salt is obtained by gradually adding hydrate of barium to a hot
rather strong solution of the normal salt. The liquid solidifies on cooling in a crys
line mass, but by recrystallisation from boiling water in a vessel protected from
carbonic acid of the air, this salt may be obtained in rather large shining prisms c
taining $C^8H^{12}Ba''N^2O^8.Ba''O + 5H^2O$. In vacuo, the crystals give off 3 at. water; w
heated to 160° C. they lose 16·4 per cent., and the residual salt contains, according
Dessaignes, 57·05 per cent. BaO, agreeing nearly with the formula $C^4H^5Ba''N$
which requires 57·55 per cent. This is the formula of the normal salt of a dib
acid; but since aspartic acid is in all probability an amidogen-acid, and such acids
always monobasic, it is rather to be supposed that the true formula of the salt d
at 160° C. is $C^8H^{12}Ba''N^2O^8.Ba''O$. This formula requires only 55·0 per cent. B
the greater proportion obtained by Dessaignes may have been due to the presenc
carbonate of barium. (Gerhardt, Traité, i. 818.)

The *normal calcium-salt* is gummy, and tastes like the sodium-salt. The *basic*
frequently forms prismatic crystals containing $C^8H^{12}Ca''N^2O^8.Ca''O + 7H^2O$; acco
ing to Dessaignes, it gives off 8 atoms of water at 160° C., and is then reduce
$C^4H^5Ca''NO^4$.

Magnesium-salts.—The normal salt forms crystalline crusts, soluble in about 16
of boiling water, insoluble in absolute alcohol. The basic salt obtained by dissolv
magnesia in the normal salt is a gummy mass.

Aspartate of Zinc is a white non-deliquescent salt. *Aspartate of nickel* is obtai
by evaporation in a green fissured mass. An aspartate of *iron* is precipitated on a
ing a solution of basic aspartate of magnesium to sesquichloride of iron.

Aspartates of Copper.—The normal salt of the active acid exists only in soluti
A basic salt is obtained by adding a solution of the normal barium-salt to a hot s
tion of sulphate of copper. The liquid on cooling deposits pale blue, very light cr
tals which, according to Dessaignes, contain $C^4H^5Cu''NO^4.5H^2O$ (or rather, perha
$C^8H^{12}Cu''N^2O^8.Cu''O + 9H^2O$), and give off their water at 160° C., leaving the an
drous salt $C^4H^5Cu''NO^4$. Inactive aspartate of ammonium forms a bluish precipit
with copper-salts. (Wolff.)

of Lead.—The normal lead-salt, $C^8H^{12}Pb''N^2O^8$, is obtained by precipi-
ion of acetate of lead with aspartate of potassium or basic aspartate of
mixing an ammoniacal solution of normal acetate of lead with inactive
odium, a curdy precipitate is formed, and the filtered liquid, if diluted
lerable quantity of water, deposits, after two or three days, nacreous
d in very hard spherical masses. These crystals are anhydrous, and
per cent. of lead-oxide, agreeing with the formula $C^8H^{12}Pb''N^2O^8.Pb''O$,
s 64·5 per cent. PbO. The formula $C^4H^5Pb''NO^4$, analogous to that of
artates examined by Dessaignes, would require 66·1 per cent. of lead-
ur). The sodium-salt of active aspartic acid also forms a precipitate with
cetate of lead, and the liquid afterwards deposits hard radiated nodules
per cent lead-oxide; these, however, are nothing but a basic acetate of
eur.)

of Mercury.—Mercuric oxide, boiled with aspartic acid, forms a white
ining, when dried at 100°, $C^8H^{12}Hg''N^2O^8.Hg''O$, a composition analogous
teur's basic lead-salt. (Dessaignes.)

of Silver.—When nitrate of silver is added to a slightly alkaline solution
f ammonium, a precipitate is formed, which disappears on stirring, and
er 24 hours, yields white, heavy, entangled crystals of a basic salt. The
, left to crystallise, deposits yellowish crystals of the normal salt,
The basic salt appears to be $C^4H^5Ag^2O^4$. This formula requires
t. oxide of silver, and the mean of several analyses made by different
not differing by more than 0·2 per cent., gives 66·7 per cent. This salt
to be really a dibasic aspartate. Pasteur finds, however, that the same
rely pressed between paper, and then dried for 24 hours at the ordinary
agrees in composition with the basic lead- and mercury-salts, its formula
$gNO^4.Ag^2O$. The active and inactive acids yield silver-salts identical in
(Pasteur.)

(?) *of Ethyl.*—When malate of ethyl is saturated with dry ammonia-
l becomes heated, and in a few days solidifies to a radiated crystalline
after being drained, and then washed with ether, consists of pure mala-
tate) of ethyl, $\left.\begin{matrix}N(H^2.C^4H^4O^2)\\ C^2H^5\end{matrix}\right\}O$. By further treatment with ammonia, it
nto malamide [? asparagine]. (Pasteur.)

OLITE. A variety of *cordierite* $[3(Mg''O.SiO^2) + Fe''O.SiO^2 +$
$^2)]$, in which the magnesia is partly replaced by water. The two
tallise in the same form, and crystals are found consisting partly of
tly of aspasiolite, the most complete transitions from one to the other
he same specimen. Moreover, both minerals contain the same propor-
and alumina; but aspasiolite contains less magnesia and more water
e, the difference being that 1 at. of magnesium in the latter is replaced
lrogen in the former (or 1 at. of magnesia by 3 at. of water). Similarly
t 1 at. of iron or manganese may be replaced by 3 at. H without altera-
line form. This kind of isomorphism, called *polymeric* isomorphism,
d by Scherer; it was first noticed in the minerals cordierite and aspa-
g. Ann. lxviii. 319.)

ANNIC ACID. A variety of tannic acid obtained by Schwartz (Ann.
xxx. 333) to be contained in woodruff (*Asperula adorata*). Schwarz
the formula $C^{14}H^9O^9$, but it does not appear to have been obtained in
ty. (See also Rochleder, Ann. Ch. Pharm. lxxxiii. 64.)

LA ODORATA. The herb of this plant contains cumarin, aspertannic
hloric acid, citric acid, and probably catechu.

T. *Compact Bitumen, Mineral Pitch, Jew's Pitch, Bitumen Judaicum,*
rdpech, Bergpech, Goudron minéral.—A smooth, hard, brittle, black,
lack. resinous mineral, having a conchoïdal fracture, and a streak lighter
ken surface with which it is made. Specific gravity 1 to 1·68. Odour
ecoming stronger by friction. Melts at about 100° C., easily takes fire,
h a bright, but very smoky flame. Like all bituminous substances, it is
he decomposition of vegetable matter, consisting chiefly of hydrocarbons,
quantities of oxygen and nitrogen, and yields by dry distillation a small
nmoniacal water, a peculiar empyreumatic oil, and a residue of charcoal
ariable quantities of inorganic matter. It dissolves partially in alcohol,
oils both fat and volatile; it is also dissolved by alkalis and alkaline

found in most parts of the world, sometimes pure, sometimes associated

with various minerals. The name *earthy* or *crude asphalt* is applied to various m
more or less impregnated with bitumen. Pure asphalt is found on the shores of
Dead Sea, issuing from the earth in the liquid state at the bottom, and rising to
surface, where it forms solid lumps, which are thrown upon the shore. In Trini
there is a lake of bitumen 1½ mile in circumference, cold and solid near the shore,
gradually increasing in temperature and softness towards the centre. Asphalt is
found, more or less pure, in Cuba, South America, and various parts of Europe.

At Seyssel, near the Rhone (Dépt. de l'Ain), it forms a deposit 2500 ft. long
800 ft. broad, yielding about 1500 tons annually. At Bechelbrunn and Lobsan
the Lower Rhine, a viscid bituminous mass is found, called *graisse de Strasbourg*, t
ther with a ferruginous sandstone, containing about 12 per cent of bituminous ma
At Bastennes and Dax, in the Département des Landes, there is a siliceous sand,
pregnated with about 6 per cent. of bitumen. In the Val de Travers, Neufch
there is a cretaceous formation, strongly impregnated with asphalt, which is use
building purposes. In the British Isles, asphalt is found at the Poldice min
Cornwall; near Matlock in Derbyshire; at Haughmond Hill in Shropshire; an
the Hotwells near Bristol; also in limestone near Glasgow; in freestone near E
burgh; in the sandstone of Caithness; and generally throughout the Orkneys.

Asphalt is separated from the minerals with which it is associated, either by bo
with water, which causes the bitumen to run out in the melted state, or by the a
of hydrochloric acid, which dissolves carbonate of calcium and leaves the aspha
with oil of turpentine, which dissolves out the bitumen.

The following table contains the results of analyses of various kinds of asp
a is asphalt from Coxitambo inPeru; *b* from Bastennes; *c* from Pont-du-Châ
Auvergne; *d* from the Abruzzi near Naples; *e* from Pontnavey; *f* from Cuba:

	Boussingault.*		Ebelmen.†			Regnault.‡	
	a		*b*	*c*	*d*	*e*	*f*
Carbon . .	88·63	88·70	78·50	76·13	77·64	67·43	81·46
Hydrogen .	9·69	9·68	8·80	9·41	7·86	7·22	9·57
Oxygen } .	1·68	1·62	2·60	10·34	8·35	23·98 }	8·97
Nitrogen }			1·65	2·32	1·02	1·37 }	
Ash . .	—	—	8·45	1·80	5·13	—	—
	100·00	100·00	100·00	100·00	100·00	100·00	100·00

According to Boussingault (Ann. Ch. Phys. [2] lxiv. 141), asphalt or com
bitumen is a mixture of two definite substances, viz. *asphaltene*, which is fixed
soluble in alcohol, and *petrolene*, which is oily and volatile. The greater part o
latter may be volatilised by distilling the asphalt with water.

Petrolene (from the asphalt of Bechelbrunn) forms, when dried over chlori
calcium and rectified, a pale yellow oil having a faint taste and bituminous o
Specific gravity 0·891 at 21° C. Does not become solid at 12° C. It stains p
and burns with thick smoke. Boils at 280°, forming a vapour of specific gravity 9
It contains, according to Boussingault, 87·2 per cent. carbon and 12·1 hydrogen, a
ing nearly with the formula $C^{20}H^{32}$, which for a condensation to 2 vols. give
vapour-density 9·5.

Asphaltene is obtained pure by heating asphalt for 48 hours to 250° C., wh
the petrolene is completely volatilised. It is a black solid substance, having a s
lustre and conchoïdal fracture. It becomes soft and elastic at about 300° C., de
poses before it melts, and burns like a resin. It gives by analysis 74·2 per ce
and 9·9 H, whence Boussingault deduces the formula $C^{20}H^{32}O^{3}$. Gerhardt p
$C^{20}H^{30}O^{3}$, and suggests that asphaltene may be formed by the oxidation of petrole

Asphalt-oil.—Asphalt yields by dry distillation, a yellow oil consisting of h
carbons mixed with a small quantity of oxidised matter. It begins to boil at 9
but the boiling point gradually rises to 250°. The portion boiling between 90°
200° has a specific gravity of 0·817 at 15° C.; that which boils between 200°
250° has a specific gravity of 0·868 at 15° C. Both portions gave by analysis a
87·5 per cent. carbon, 11·6 hydrogen, and 0·9 oxygen, which is nearly the compo
of oil of amber. (Völckel, Ann. Ch. Pharm. lxxxviii. 139.)

Asphalt-oil, treated with nitric acid, is transformed into a resin, having the o
of musk and the taste of bitter almonds. On treating the oil with strong sulp
acid, part dissolves, while the rest floats on the surface. This latter, when deca
washed with potash, and rectified, yields an oily mixture, whose boiling point r
from 90° to 250° C., and density from 0·784 to 0·867 at 15° C. Subjected to
tional distillation at intervals of 20° or 30° C., it yields a number of oils grad

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* Ann. Ch. Phys. [2] lxxiii. 442. † Ann. Min. xv. 523. ‡ Dingl. polytechn. J. lxviii.

nsity, but agreeing very nearly in composition, the mean result of their 37·5 per cent. carbon, and 12·5 H, a proportion agreeing with the It agrees also with Boussingault's analysis of petrolene. All these the same odour, are insoluble in water, but very soluble in alcohol ng sulphuric acid scarcely attacks them. They are insoluble in strong on boiling the liquid, the nitric acid volatilises, and there is formed a ity of a heavy yellow oil.

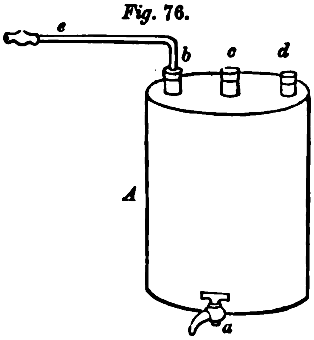
sed by the ancient Egyptians in embalming, and appears to have been e construction of the walls of Babylon. It is now used, mixed with nd sandstone, &c., for pavement, for making water-tight tanks and ng for tubes of glass and iron used for conveying gas or water, and for rposes of like nature.

Gas-tar Asphalt is a mixture of sand, chalk, or lime-stone, with the due obtained by evaporating off the more volatile portions of gas-tar. stance must be strongly heated to expel moisture and adhering air, which would prevent the pitch from penetrating thoroughly into the neral, and added to the pitch while in the melted state. The pitch ery strongly heated, but not enough to char it. This artificial asphalt me way as the natural asphalt, for pavements, tanks, &c.

US. The bulbs of *Asphodèle de Sardaigne*, of *Asphodelus racemosus*, s of the same genus, are said to contain a fermentable substance from ay be prepared. According to Landerer, an excellent glue may be he bulbs of *A. racemosus* and *A. fistulosus* by washing them with hem thoroughly in a stove, grinding them to coarse powder, and ler with water.

R. An apparatus first devised by Brunner for drawing a stream of ube or other vessel. The simplest form of it is a cylindrical vessel inc or tin plate to hold water, having a cock *a* near the bottom, and closed with corks *b*, *c*, *d* on the cted with the vessel through n of air is to be drawn; *c* is for a thermometer, and *d* to pour vessel *A* being filled with water, and *d* closed, and the *cock a* r runs out; and as air can only ent tube *e*, inserted into the am of air is drawn through the which the other end of this tube e volume of air thus drawn exactly equal to that of the ns out at *A*. Instead of the a glass vessel may be used, ock at the lower part of its

Fig. 76.



n his analysis of air, used a cy- essel with conical terminations, he bottom, a stopcock to which was attached a short glass tube bent the small column of liquid which remained in it when the vessel was r might prevent air from entering at the bottom The advantage of the tions is that the vessel can be more completely filled and emptied, of water which runs from it, more exactly measured.

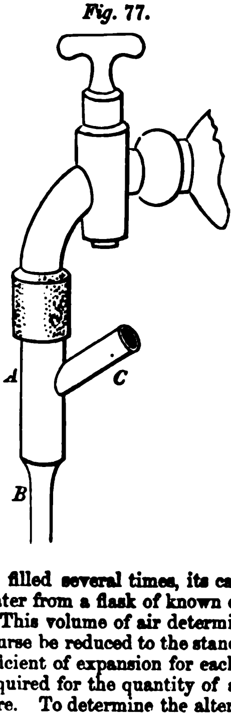
forms of aspirator, the refilling of the vessel with water is very pecially when large quantities of air are to be drawn through. To onvenience, an aspirator has been contrived by Brunner, consisting of drical vessels placed one above the other and communicating by tubes pened or closed, so that, when the water has run from the upper to , the apparatus, turning for the purpose on a horizontal axis, may be to bring the empty vessel to the bottom, and the full one to the top; then be again made to run without the trouble of refilling.

ator has the form of an ordinary gasometer, consisting of two cylindrical r of which, of rather smaller diameter than the outer, is closed at top, the outer which contains water. The inner vessel is balanced by a over a pulley, as in the large gasometers used at gas-works. The vessel the air is to be drawn is connected with the inner vessel by a bent rough the outer vessel near the bottom and terminating within the

A simple apparatus, serving both for aspirator and perspirator is described F. Guthrie (Phil. Mag. [4] xv. 64).

An aspirator which works by a constant stream of water and does not any filling or emptying of vessels, has been contrived by M. W. Johnson (Soc. Qu. J. iv. 186). The principle of this apparatus is the same as that of the blast used in the Hungarian mines. The app consists of a small hollow cylinder *A*, of brass or open at both ends, and connected with the through which the air is to be drawn, by the tube *C*. A straight glass tube *B* is fitted to the end of the cylinder *A*, and the upper end cylinder is attached by a caoutchouc tube to a tap supplying a constant stream. On opening t the water, as it runs down, carries the air in the der *A* along with it and the air in the lateral is then driven in by the external pressure. manner, a stream of air is made to pass from *C* long as the water is running. It is best not t the tap to the full. For a cock ⅜ of an i diameter, the cylinder *A* may be 2 in. long an wide; *B* 1 in. long and ⅜ in. wide; *C* also 1 i and ⅜ in. wide. The volume of air drawn throu aspirator is not equal to that of the water whic away. With the tube *B*, 8 in. long and ⅜ in. wide son found that, for every cubic foot of air drawn i 0·69 cub. in. of water was expended. It is therefore, that this form of aspirator cannot b when the volume of air drawn in is to be measured. In that case one of the aspirators bef scribed must be used. When only small quant water are run out, it is sufficient to receive the in a graduated measure and determine its directly. When a large aspirator is used and be filled several times, its capacity must be previously determined by filling i water from a flask of known capacity.

Fig. 77.



This volume of air determined by direct measurement of the water run out, course be reduced to the standard pressure and temperature, 0° C. and 760 mm., efficient of expansion for each degree centigrade being 0·003665. A correction required for the quantity of aqueous vapour in the air, which is saturated with ture. To determine the alteration of volume thus produced, we must look in the of the tension of aqueous vapour for the tension corresponding to the observe perature. Let this tension expressed in millimetres of mercury be f; also let h the height of the barometer, t the temperature in centigrade degrees; v the ob and v' the corrected volume of the air: then

$$v' = v.\frac{h - f}{760}.\frac{1}{1 + 0{\cdot}003665\,.\,t}$$

ASSACOU or **USSACU.** The Brazilian name for the *Hura brasiliensis* a euphorbiaceous tree, the bark and sap of which contain an acrid very poi principle. The thickened sap and the decoction of the bark exert an emetic produce ulcerating pustules on the skin, and are used as a remedy for elephan The natives also use them to prepare poisonous drinks, against which no anti known. (Mérat and Gilbert, Pharm. Centr. 1849, p. 30.)

ASSAMAR. (From *assare* to roast, and *amarus* bitter.) This name was by Reichenbach to the peculiar bitter substance produced when gum, sugar, gluten, meat, bread, &c. are roasted in the air till they turn brown. Reichen (Ann Ch. Pharm. xlix. 3) prepares it by roasting thin slices of bread till they b black-brown, treating the pulverised product with absolute alcohol, evaporatin syrup, again treating with alcohol, &c. till a residue is obtained completely solu alcohol. The alcoholic solution is then mixed with ether, which precipitates a p brown substance; the decanted liquid is evaporated; and the residue carefully till it is dry. Völckel (Ann. Ch. Pharm. lxxxv. 74) prepares assamar in a s manner, from the brown tarry liquid obtained by the dry distillation of su caramel, after neutralising the acid contained in the liquid with carbonate of so and evaporating.

Assamar, according to Reichenbach, is a yellow transparent solid; but acco

a reddish-yellow syrupy liquid, which does not solidify till it begins
It is extremely hygroscopic, and dissolves in water in all proportions.
melts (Reichenbach), becomes more fluid, and at 100° C., decomposes
arker in colour, after which it no longer dissolves completely in water
he aqueous solution is neutral, and reduces nitrate of silver when
ar is dissolved by potash, and acids precipitate from the solution, a body
position. Völckel assigns to assamar the formula $C^{24}H^{13}O^{18}$; but it is
er the substance so-called is a definite compound, or has ever been
pure state.

IPOLIUM. *Sea Starwort.*—The ash of this plant, which grows in
very rich in chloride of sodium. The several parts of the plant
ds the end of September, were found by Harms (Ann. Ch. Pharm.
eld ash of the composition and amount given in the following table:

	Root-leaves.	Stems.	Stem-leaves.	Flowers.
. . . . .	14·9	8·7	16·2	9·4
100 pts., after arcoal and sand:				
cid (anhyd.) .	3·4	3·3	4·2	3·7
acid (anhyd.) .	2·7	1·8	4·1	10·5
acid (anhyd.) .	2·0	0·6	1·7	10·8
yd.) . . .	0·6	0·5	0·8	1·0
f sodium . .	65·5	68·5	60·2	30·0
f potassium .	3·7	14·1	—	—
. . . . .	—	—	14·0	1·4
. . . . .	13·6	2·5	6·1	25·4
. . . . .	5·0	4·5	4·8	7·2
. . . .	2·2	2·2	1·7	5·7
phate of iron . .	1·1	2·1	2·3	4·0
-manganic oxide .	trace	trace	trace	trace

ITE. A native sulphate of magnesium and sodium, $SO^4(Mg'';Na^2).2H^2O$,
hite, opaque, prismatic crystals, together with ordinary sulphate of
the bitter salt-marshes on the eastern side of the mouth of the Volga.

TE. A glass flux resembling aventurin, but containing crystals of a
und, which by reflected light exhibits a dichroitic iridescence of dark
h-blue. To prepare it, a mixture of 80 pts. of silica, 120 lead-oxide,
f soda, and 18 anhydrous borax, is fused either with 24 pts. of scale
, and 1 pt. of scale oxide of iron, or with 5 pts. of lime, 26 scale oxide
2 scale oxide of iron. The mixture is fused in a hessian crucible, at
ordinary air-furnace, and left to cool slowly in the furnace. The first
nore easily than the second, and yields larger crystals. The dichroitic
particularly beautiful on cut and polished surfaces. (Pettenkofer,
turw. techn. Commission bei d. Akad. d. Wiss. zu München, p. 134.)

YLLITE. A variety of mica found at Brevig in Norway It con-
umina, ferric oxide, magnesia, potash, soda (a trace), ferrous oxide,
ide, lime, and about 3 per cent. of water. The amount of iron is
. Fluorine is absent. Before the blowpipe it melts easily, and with
Colour pinchbeck-brown, varying to nearly a golden-yellow in the
The crystals are often united in beautiful stellate and floral groups:
. (Scheerer, Berg- u. hüttenmannische Zeitung, 1854, s. 240.)

ITE. A native oxychloride of copper. originally found in the desert
Peru, and since observed in other localities, viz. in some silver mines in
istricts of Huasco Bajo and Aconcagua in Chili, in the lavas of Vesu-
e mines of Schwarzenberg in Saxony. According to the analyses of
Davy, Ulex, and Mallet, it contains $Cu''Cl^2.3Cu''H^2O^2$, or $CuCl$ +
Berthier (Rammelsb. Handw. i. 55) found in a specimen from Cobija
nt of water given by the above formula. F. Field (Chem. Soc. Qu. J.
es from his analysis of a specimen from Copiapo in Chili the formula
+ $5HO$, or $Cu''Cl^2.3Cu''H^2O^2 + 2H^2O$. It forms small rhombic crystals,
ur from leek to emerald green, and generally aggregated in crystalline
ding to Monteiro (Phil. Mag. [4] xiii. 470), it occurs at Serra do
mbriz, on the west coast of Africa, in small translucent crystals,
alachite and quartz. It dissolves easily and completely in acids, and
It is used for the extraction of copper.

ATHAMANTA OREOSELINUM. The root and seeds of this plant
a peculiar bitter substance, not yet examined, together with athamantin (
article). The leaves contain, not athamantin, but a bitter principle and a vol
which is obtained by distilling the herb with water. This oil has the compo
oil of turpentine, $C^{10}H^{16}$; it smells like elder, has a density of 0·841, and
163° C. With hydrochloric acid gas, it forms an uncrystallisable liquid,
colourless after distillation, lighter than water, and boils at 190° C. It does no
to be related, in composition or properties, either to athamantin or to oil of
which is produced by the decomposition of the latter. (Schnederma
Winckler, Ann. Ch. Pharm. li. 336.)

ATHAMANTIN. $C^{24}H^{30}O^7$. (Gm. xii. 101; Gerh. iv. 269.)—A substan
ing in the root and seeds of *Athamanta oreoselinum*, and other species of the sam
It was first obtained in an impure state by Winckler (Buchn. Repert. xx
afterwards prepared pure and more completely examined by Schnederman
Ch. Pharm. li. 315). It is extracted by treating the roots and seeds with
The solution, if not too concentrated, yields the athamantin, by spontaneous
tion, in crystals, which may be purified by pressure and recrystallisation.
colourless, fibrous, silky crystals, or sometimes rectangular prisms with truncat
mits; has a rancid soapy odour, and a slightly bitter acrid taste. It is inso
water, and melts in it at the boiling heat, in drops which sink to the botto
vessel. It dissolves readily in alcohol and ether, and the solutions are not pre
by metallic salts. It melts between 60° and 80° C. It does not volatilise u
posed, although it can sustain a tolerably high temperature without decom
By dry distillation, it yields valerianic acid and other products.

Melted athamantin absorbs hydrochloric acid gas, and appears to enter i
bination with it, but on raising the temperature to 100° C., decomposition tak
and the athamantin is resolved into valerianic acid and oreoselone:

$$\underbrace{C^{24}H^{30}O^7}_{\text{Athamantin.}} = \underbrace{2C^5H^{10}O^2}_{\substack{\text{Valerianic}\\ \text{acid.}}} + \underbrace{C^{14}H^{10}O^3}_{\text{Oreoselone.}}$$

When hydrochloric acid gas is passed into an alcoholic solution of athama
products formed are oreoselone and valerate of ethyl. Sulphurous acid acts on a
tin like hydrochloric acid, a crystalline compound being formed at first, and so
wards oreoselone, valerianic acid, and sulphurous acid gas. Concentrated sulph
dissolves athamantin and decomposes it in like manner. Athamantin hea
caustic potash, yields valerate of potassium, and a white amorphous substanc
appears to be a hydrate of oreoselone. Lime-water and baryta-water act in
manner, but more slowly. (See OREOSELONE and PEUCEDANIN.)

Trichlorathamantin, $C^{24}H^{27}Cl^3O^7$, is a light yellow resinous body, produced b
an alcoholic solution of athamantin with water, and cautiously adding dilute
water, till the liquid smells slightly of chlorine. A corresponding bromine-c
appears to be formed by treating athamantin with bromine-water.

Trinitrathamantin, $C^{24}H^{27}(NO^2)^3O^7$, is formed, together with other sub
products, by the action of cold fuming nitric acid on athamantin. Precipi
water, it is a yellow pulverulent substance, scarcely wetted by water, easily
alcohol, ether, and ammonia, slightly in dilute nitric acid. (Geyger, Ann. Ch
cx. 359.)

ATHANOR or **ACANOR.** *Piger Henricus*, *Fourneau des paresseux.*-
of furnace, which has long since fallen into disuse. The long and tedious o
of the ancient chemists rendered it a desirable requisite, that their fires s
constantly supplied with fuel in proportion to the consumption. The athano
was peculiarly adapted to this purpose. Beside the usual parts, it was provi
a hollow tower, into which charcoal was put. The upper part of the tow
filled, was closely shut by a well-fitted cover; and the lower part communica
the fire-place of the furnace. In consequence of this disposition, the char
sided into the fire-place gradually as the consumption made room for it;
which was contained in the tower was defended from combustion by the exc
a proper supply of air.

ATHAR or **ATTAR.** The Indian name of volatile oil of roses.

ATHERIASTITE. The name given by Weibye to a mineral from
bearing an external resemblance to scapolite. In composition it appears to b
to epidote, as will be seen by the following comparison of its analysis by
(Pogg. Ann. lxxix. 302) with that of epidote from Arendal by Scheer
xcv. 503).

	Atheriastite.	Epidote.
Silica	38·00	37·59
Alumina	24·10	20·73
Ferric oxide	6·22	16·57
Lime	22·64	22·64
Magnesia	2·80	0·41
Water	6·95	2·11
	100·71	100·05

t state whether the iron in atheriastite is present as a ferrous or as a d; but it is probably all in the form of ferric oxide. (Scheerer, Handw. ufl. i. 405.)

RE. See MALACHITE.

PAR. See SATIN SPAR.

THRIN. The name given by Kane (Compt. rend. ix. 656) to a pro- atilises in red vapours, and condenses in reddish-green laminæ, in the dry litmylic acid (erythrolitmin) and litmic acid (a mixture of azolitmin in), with lime.

SCOPE. An instrument invented by Babinet (Compt. rend. xxvii. re the rate of evaporation.

HERE. The gaseous envelope which surrounds any solid or liquid an atmosphere (ἀτμός smoke, σφαῖρα globe); thus we speak of the atmo- en which spongy platinum attracts to its surface, or of the reduction of atmosphere of hydrogen. The term atmosphere is, however, especially esignate the gaseous matter which encircles the solid and liquid portions surface, forming the air or earth's atmosphere.

tence of matter above the visible crust of the globe we have striking he resistance offered to bodies moving near the earth's surface and produced by wind; but the most direct proof that the air is attracted and liquid portions of the earth's body, or that the air has weight, is e fact that a vessel filled with air weighs more than the same vessel e air has been removed, and that a closed vessel filled with air weighs nosphere than it does in a vacuum. That the air possesses weight was before the time of Aristotle; but Galileo, in 1640, was the first who gave lanation to the fact observed by the Florentine pump-makers, that they o raise water by a suction-pump more than 32 feet, and supposed by that nature had a "horror vacui." Galileo's explanation was beauti- by his pupil Torricelli, who argued that, if the atmospheric pressure umn of water 32 feet in height, it must support a column of mercury, ly fourteen times heavier than water, of about 30 inches in height; first barometer was constructed, the empty space above the mercury in called, from its discoverer the, *Toricellian vacuum.*

here, then, having weight, or obeying the laws of gravitation, forms a th's body, and accompanies the solid and liquid portions in their axial otions. The height to which the atmosphere extends above the earth's the same at all points, since, owing to the increase of the attractive poles and its diminution at the equator, and to the action of the rce, as also to the increase of temperature, the atmosphere presents, 's solid body, the form of a spheroïd, whose polar is considerably ts equatorial diameter. The absolute height to which the atmosphere e any point on the surface of the earth has not been determined ree of certainty: for, as air is an expansive fluid, and the volume n quantity of air occupies is directly dependent upon the pressure ure to which it is exposed (in accordance with the known laws regu- ansion and contraction of gases), the density of the atmosphere is not diminishes as the distance from the earth's surface increases: the t which the atmosphere terminates is thus very difficult to determine. however, a limit of the earth's atmosphere is rendered certain from the ed by the observations of the occultations of stars or satellites, that our st of the planets are destitute of an atmosphere like ours, which he case if the terrestrial air were diffused throughout space. Dr. Wol- d that a gas cannot expand beyond a certain limit, and Faraday has the case of the vapour of mercury such a limit really exists: hence no doubt that there is a definite limit to the atmosphere; and, from the time during which the twilight extends to the zenith, it appears that the atmosphere reaches, in a state of sensible density, to the mean height of forty to forty-five miles above the earth's surface.*

Barometric observations at various heights above the sea-level prove conclusi that Galileo's theory of atmospheric pressure is correct. The first of these barom measurements, made on the Puy-de-Dôme by Pascal's advice in 1648, showed that column of mercury supported by the atmosphere sinks as the distance from the ea surface increases; thus, at the sea-level, the mean height of the barometric colum 760 millimetres (29·92 English inches), whereas in Potosi, at a height of 13,220 feet, mercury sinks to a mean level of 471 millimetres. The average weight, then, of atmosphere at the level of the sea is, in our latitudes, that of a column of mer 760 mm. in height, or equal to a pressure of 103·33 kilogrammes on a square metre (nearly 15 pounds on a square inch). This weight, the human body, in com with all substances existing at the bottom of the ocean of air, has to carry; although it may at first sight appear remarkable that the animal frame should be without discomfort to bear a pressure amounting to several tons, yet it is certain not only is this the case, but that our bodies are arranged so that we cannot exist out this pressure; and as an effect of the weight of the air, it has been shown by brothers Weber, that the human thigh-bone is, in certain positions of the body tained in its place, together with the ball and socket hip-joint, only by atmosph pressure; it is well known also that persons remaining for any length of time at g heights above the earth's surface are inconvenienced by hæmorrhage from the eyes, and mouth, owing to the small blood-vessels, unsupported by the atmosph pressure, being unable to withstand the forcible propulsion of the blood through system.

The relation according to which the density of the air diminishes in ascendin easily deduced from the well-known law of Mariotte, that the density of a is directly proportional to the pressure to which it is subject; whence it follows alterations of temperature and variations in the force of gravity at different hei not being considered, the density diminishes in a geometrical ratio, as the height creases in an arithmetical ratio. It has been found by experiment that, when barometer stands at a height of 760 mm. it is necessary to ascend 10·5 metre order to effect a fall of 1 millimetre in the barometric column, or to bring the mer to stand at 759 mm., or at $760 \cdot \frac{759}{760}$ mm. Now we may assume, without ap ciable error, that the air throughout this space of 10·5 metres is of equal den at a height, then of 10·5 metres the pressure is $760 \cdot \frac{759}{760}$: hence the air in the 10·5 metres has only a density of $\frac{759}{760}$ of what the lower layer had; and there in ascending through the second 10·5 metres, the barometer does not fall 1 millim but only $\frac{759}{760}$ of a millimetre, so that at a height of twice 10·5 metres, the barom will stand at $760 \cdot \frac{759}{760} - \frac{759}{760} = 760 \cdot \left(\frac{759}{760}\right)^2$; and as the density of the third of 10·5 metres is $\frac{759}{760}$ times less than that of the second, the barometer at the he of three times 10·5 metres, will be $760 \cdot \left(\frac{759}{760}\right)^2 - \left(\frac{759}{790}\right)^2 = 760 \cdot \left(\frac{759}{760}\right)^3$, and so on. then, at two places the barometer stands respectively at $B = 760 \cdot \left(\frac{759}{769}\right)^n$ $B' = 760 \cdot \left(\frac{759}{760}\right)^m$, their difference in elevation is 10·5 m × $(n - m)$; hence, these two equations the difference in height, H, between these two points expresse metres is

$$H = 18363\,(\log B - \log B')$$

or in English feet

$$H = 60246\,(\log B - \log B').$$

By means of this formula, we find that the pressure is diminished to half its orig amount, and therefore the air expanded into double its original volume, at a heig 5528 metres or 18,136 ft. above the level of the sea, and that at a height of t 5528 metres, the pressure is reduced to ¼ of its original amount, and so on.

The mean temperature of the atmosphere, like its density, is not equal throug the mass, but diminishes as the distance from the earth's surface increases, so tha a certain height above the sea-level, different for different latitudes, we arrive

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* In order to give an idea of the relation between the earth's diameter and the height of the sphere, it may be stated, that if we represent the earth by a globe of 1 foot in diameter, the atmosp will be represented by a layer of air $\frac{1}{12}$ of an inch in height.

ich the mean temperature of the air does not rise higher than the freezing
is line is called the level of perpetual snow. This regular diminution of
in the higher regions of the atmosphere is to be attributed mainly to two
o the fact that the air absorbs but a small portion of the heating rays of
eir passage to the earth, the lower zones of the atmosphere being heated
th the warmer solid and liquid crust of the globe; and, secondly, to the
tent heat which all gases undergo on rarefaction, producing a diminution
e. Besides this regular alteration of mean temperature of the various
bove the earth, the various portions of the atmosphere exhibit great and
ation in temperature, owing to the unequal heating effects produced by
he earth in various latitudes and at various times. The mean tem-
ny place, and therefore of the air above that place, is the resultant of the
eat received from the sun, and that lost by radiation. These two con-
s are, however, never constant, either in the same or in different places,
e temperature is continually varying. The chief factor representing the
perature, is the height to which the sun rises above the horizon, and the
h which any point on the earth's surface is heated, is proportional to the
sun's zenith-distance at that point; thus, in the torrid zone, the sun's
ce varies from 0° to 33°·5, or the cosine from 1 to 0·917, whilst in the
d frigid zones the cosine of the angle varies from 0·930 to 0·367, and
0. We see from these numbers that, although many other circum-
as duration of day and night, and the thickness of atmosphere through
n's rays have to pass affect the temperature, the warm climate of the
not subject to such variations as occur in the other portions of the globe.
t which the mean atmospheric temperature sinks below 0° C., or the
e snow-line, in different latitudes, is determined by many circumstances
already mentioned, as, for instance, the geographical relations of the
hbourhood of large masses of water, &c.; thus the snow-line on the
e of the Himalaya is found at a height of 15,600 ft., whilst on the southern
es only 12,200 ft. above the sea. Still the general descent of the line of
w with increase of latitude is, notwithstanding these local irregularities,
thus, under the equator, the snow line is not reached until 15,207 ft.,
er the latitude of 60°, it is found at 3818 ft., and in latitude 75°, at
above the sea-level.

through the atmosphere, a portion of the solar rays is absorbed, the
s absorption depending upon the thickness of the layer of air through which
Pouillet (Pogg. Ann. xlv. 25 and 481) concluded, from his own ex-
at when the sun is in the zenith and the atmosphere clear, the amount
eat which is absorbed by passing through the air, varies from 18 to 25 per
uantity which enters the atmosphere.

f the sun is also partially absorbed and reflected in its passage through
according to Clausius (Pogg. Ann. lxxii. 294), out of 1000 rays of direct
ring the atmosphere, 750 reach the earth direct, whilst 186 are reflected as
and 64 are absorbed. For the more refrangible chemically active rays,
Roscoe have lately determined the amount of atmospheric absorption and
r the numerical results of these experiments the reader is referred to the
e Chemical Action of Light. Besides suffering absorption and reflection,
light which enters the atmosphere otherwise than perpendicularly to the
ce, undergoes refraction, or is bent out of its course in the direction of the
um, so that, as we see the object in the direction of the tangent to the
ters the eye, all celestial objects appear higher than they really are. Ac-
e experiments of Biot and Arago, the refractive index, from the absolute
air at 0° C. and 0·76 m. pressure of mercury, is 1·000294; and hence the
wer of the air is equal to 0·000588.*

he unequal heating effect which the sun produces on the various portions
s surface, either from general or local causes, the temperature of the
varies in every part of the globe, and in the same part undergoes
ange, thus producing the motion of masses of air which we call wind.
variably caused by the ascent of a heated mass of air, and the motion of
s to fill up the space thus left vacant; the former of these gives rise to
he higher regions of the atmosphere, whilst the latter produces the hori-
ts which we observe at the surface of the earth. Winds may either be con-
narrow limits, as for example the sea and land breezes seen on every coast,
xtend over a large portion of the globe, as is the case with the trade winds.
re caused by local circumstances depending upon the unequal heat-absorb-

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f the index of refraction be = n, the refractive power is n^2-1. See Light.

ing and radiating power of the sea and land, whilst the latter depend upon the unequ distribution of temperature throughout the globe, being caused by the rise of hot from the equatorial zones, inducing horizontal currents to stream in from the colder pol regions. These polar currents would, if the earth were at rest, move directly sou and north to the equator; but, owing to the earth's axial motion from west to ea they pass continually over latitudes having a velocity of rotation greater than that the current, which therefore acts as a resistance towards the east, or as a north- south-east wind.

Composition of the Atmosphere.

It was not until the year 1774 that the true composition of the atmosphere w pointed out by Lavoisier. Before this time, the air was spoken of as one of the fo elements, together with fire, earth, and water; and it was only during the few yea preceding this date that the vague impressions of speculative philosophers were e changed for the careful observations of Priestley and Scheele, whose discovery oxygen had paved the way for the knowledge of the exact composition of the atm sphere. In November 1774, having the advantage of acquaintance with Priestley previous discovery of the vital air procured from red precipitate, Lavoisier announc to the world that the atmosphere consists of two gases, one of them being essential life, and the other incapable of supporting respiration or combustion. These two gas he named *oxygen* (ὀξύ, acid, and γεν to give rise to) and *azote* (α privative, a ζωή, life) or *nitrogen*, and he found that the first of these gases occupies about one-fi by bulk of the atmosphere, the other occupying the remaining four-fifths. Besid these two gases, which form by far the largest portion of the atmosphere, many oth substances occur in the air, which although present in comparatively small quantiti play so important a part in the action of the atmosphere on our globe that th cannot be regarded as accidental constituents: these substances are, *aqueous vapo carbonic acid*, *ammonia*, and *organic decomposing matter*. The atmosphere also co tains traces of very many other bodies which may be considered as foreign or acciden constituents, such as nitric acid, sulphurous acid, carbonic oxide, hydrocarbons and min solid particles which are seen floating about in the air by the light of a sunbeam.

Since the time of Priestley, Scheele, and Lavoisier, the determination of the quan tative composition of the atmosphere has been made the subject of experiment many of the most eminent chemists of the present century; but in spite of th numerous investigations, the relative distribution of the component gases of the atm sphere is still but imperfectly known.

At the commencement of this century, there was much difference of opinion amon scientific men as to the true composition of the atmosphere: Prout, Döbereiner, a Thomson considered the atmosphere to be a chemical compound of 20 volumes oxygen, and 80 volumes of nitrogen, whilst Dalton (Manchester Memoirs, 2 S vol. i. p. 244) contended that the atmosphere is a mere mechanical mixture, but s posed that the relative amounts of the two gases varied according to their spec gravities at different heights above the earth's surface, the oxygen increasing quantity the nearer the sea-level was approached, and the amount of nitrogen beco ing larger as the distance from the surface of the earth increased.

That the determination of the amount of oxygen which air in different localit contains, should have excited the interest of men of science as soon as the discovery the true composition of the air was made, does not seem remarkable, when we bear mind the direct dependence of all life upon this element, and the great influence wh even slight alterations in the amount of atmospheric oxygen might produce on animal life subjected to this change, and hence Eudiometry (εὔδιος, good, εὐδία, serene and μετρεῖν, to measure), or the mode of measuring the quality of the air, quickly beca a new and important branch of chemical analysis. At first sight it appeared not unlik that the unequal development of animal life on the various parts of the globe, wou effect considerable alterations in the composition of the air in different localities; a this idea was borne out, not only by the well-known fact of the unhealthiness of air of certain districts, such as crowded towns, marshes, and the like, but also by earliest determinative experiments, which showed variations in the composition of of various localities amounting to nearly 10 per cent. Thus Fontana determined quantity of oxygen contained in air by absorption with nitric oxide, and obtain results showing from 18 to 25 per cant.; whilst Scheele, on absorbing the oxygen w sulphide of potassium, or by a mixture of sulphur, iron, and water, found from to 33 per cent. of that gas present in air. Other experimenters, however, a among them Dalton, Gay-Lussac, Davy, and Boussingault found, on employing oth analytical methods, that the amount of the atmospheric oxygen varied but very sligh in different situations, and that the non-accordance of the results formerly obtain was owing to errors of experiment, caused by the use of imperfect methods. T f oxygen found by Dalton in English air was from 20·7 to 28 per cent., and c and Humboldt found that Paris air contained from 21·1 to 20·9 per cent.; y in London obtained from 20·8 to 21·1 per cent.; Thomson in Glasgow, Kupffer, in Kasan, 21·1 per cent. of oxygen. Experiments made by Dalton the composition of mountain air, did not tend to confirm his theory as to the of the relative quantity of oxygen at great heights; and further experience at Dalton's views, although theoretically correct for an atmosphere of mixed est, are not applicable to the air in motion: for Gay-Lussac and Thénard he air which the former savant collected in his celebrated balloon ascent at 7000 metres, and they found that the oxygen amounted to 21·6 per cent. xactly with an analysis of the air of Paris, made in the same way at the , both differing, however, owing to a common error of experiment, from the t of later observers. Although from these experiments we can draw the conclusion that, within certain very small limits, the air has throughout its stant composition as regards oxygen, still the observational errors of these estigators were large, and it was evidently necessary that the composition of here should be determined with all the precision that modern science could The more recent labours of Dumas and Boussingault, Regnault, Bunsen, and e attained this end by help of methods in which the maximum error is $\frac{1}{3000}$.

alysis of air may be conducted in two ways. Either by measuring the the component gases, or by determining their weight. The details of the for- eudiometric method, are fully described in the article on ANALYSIS OF GASES, s the method adopted, with slight variations, by Regnault, Bunsen, and lst the determination by weight has been employed by Dumas and Boussin-

purpose of carrying out the analysis of air, these two French chemists Phys. [3] iii. 257], employed an apparatus in which air previously freed ous vapour, carbonic acid, and ammonia, by passing through U-tubes con- lphuric acid and potash, was passed through a weighed tube containing pper kept at a red heat, and then entered an exhausted balloon, the weight ad been accurately determined. The difference of weight of the tube before he experiment, was due to the oxygen; that of the balloon, to the nitrogen of ich passed into the apparatus. This process, conducted with every possible , showed the composition of the atmosphere to be:

	Percentage of oxygen by Weight.	
1841.	Small balloon.	Large balloon.
27th April	22·92	22·92
28th „ . . .	23·03	23·09
29th „ . . .	23·03	23·04
	22·993	23·016

ts by weight of air, are composed of 23 parts of oxygen, and 77 parts of From this composition by weight, the composition by volume of the air can ined when the specific gravity of the oxygen = o and that of the nitrogen iven: for $\frac{23}{o} + \frac{77}{n} = \frac{100}{1}$. Dumas and Boussingault found, on employing gravities as obtained by Berzelius and Dulong, that the sum was not 100 hence they concluded that these specific gravities must be incorrect, and l them again, obtaining o = 1·1057, and n = 0·972, from which the com- y volume of the atmosphere was found to be

$$\begin{array}{lcr} \text{Oxygen} & = & 20{\cdot}81 \\ \text{Nitrogen} & = & 79{\cdot}21 \\ \hline & & 100{\cdot}02 \end{array}$$

approximation of these numbers to the truth, has since been proved by the experiments of Regnault (see Regnault's work on Steam, p. 151; or Pogg. . p. 202), who has shown that one litre of air at 0° C. and 0·76 m. pressure, moisture, carbonic acid, and ammonia, weighs 1·293187 grms., whilst one litre under like circumstances, weighs 1·429802 grms., or has a specific gravity of nd 1 litre of nitrogen at 0° C. and 0·76, weighs 1·256167 grm., or has a specific 0·97137. In accordance with these results, Boussingault found in air which d in South America, the following percentage volumes of oxygen:

Santa Fé de Bogota,	at a height of	2650	m. above sea-level	20·65 p. c. O.
Ibaquè	„ „	1323	„ „	20·70 p. c. O.
Mariquita	„ „	548	„ „	20·77 p. c. O.

The eudiometric determinations of Bunsen and Regnault are on the whole to preferred to any method of analysis of the air by weight, not only from their great accuracy, but from the simplicity of the apparatus employed, and the ease with whi small samples of air collected at various times and in different localities can thus analysed.

Bunsen (Gasometry, p. 71), in a series of analyses of air made on fourteen differe days in January and February 1846, amongst which the maximum amount of oxyg was 20·97 per cent. and the minimum 20·84 per cent., found a mean of 20·93 per cent. oxygen.

Regnault (Ann. Ch. Phys. [3] xxxvi. 385) has analysed a very large numb of samples of air collected in various quarters of the globe in a uniform mann according to instructions given by him. The method of analysis employed rar gave a difference of 0·02 per cent. on the same sample of air. In more than hundred analyses of air collected in or near Paris, Regnault found a maximum amou of 20·999 vols. of oxygen, and a minimum of 20·913 or a mean of 20·96. This diff ence of 0·086 per cent. is, according to Regnault, too large to be accounted for by perimental errors.

9 samples from Lyons, Montpelier, Normandy gave from	20·918 to 20·966 p.c. of
30 samples collected in Berlin contained . . .	20·908 „ 20·998 „
10 „ „ Madrid „ . . .	20·916 „ 20·982 „
23 „ from Geneva and Chamounix . . .	20·909 „ 20·993 „

Of seventeen samples of air collected in Toulon Roads and other parts of the Me terranean, fifteen gave similar results of 20·912 to 20·982 per cent. oxygen, whilst samples collected from Algiers harbour contained only 20·42 and 20·395 per ce This abnormal result cannot be accounted for, but a similar phenomenon was observ by Lewy.

5 samples taken on the voyage from Liverpool to Vera Cruz gave	20·918 to 20·965 p. c. of
2 samples from Ecuador in S. America contained .	20·96 „
2 „ the summit of Pichincha, higher than Mont Blanc	20·949 to 20·988 „

Eleven samples collected in the Asiatic seas from 1848 to 1850, all except two, normal results. On the 1st February 1849, the air in the Bay of Bengal contained 20·46 and 20·45 per cent. oxygen, and on the 8th March 1849 the air from above Ganges, collected during foggy weather, in presence of much decomposing ani matter, temperature 35° C., when cholera was commencing, contained from 20·390 20·387 per cent. of oxygen.

Air collected by Captain Sir James Ross in the Arctic seas gave the normal co position from 20·86 to 20·94 per cent. oxygen. The conclusion which Regnault dra from all these determinations, is that the atmosphere shows perceptible, though small, alterations in the amount of oxygen at different times and in different plac This variation ranges from 20·9 to 21·0 per cent., but from special unknown causes tropical countries, the amount of oxygen may sink as low as 20·3 per cent. Bunse analyses of the air in Iceland confirm these views.

Lewy (Ann. Ch. Phys. [3] xxxiv. 1) has also published a series of analyses of collected from various parts of the globe. The relative amounts of oxygen and nitrog were determined by Regnault's eudiometric process, and the maximum difference tween the composition of the same sample of air analysed at different times was $\frac{1}{100}$ The air of Paris contained, in a mean of three experiments, 21·014 per cent. of oxyg that of Havre 20·888 per cent., whilst that collected on the Atlantic gave 20·961 a 21·061 per cent., and in South America, 20·995 and 21·022 per cent. of oxygen. He we can positively state that no greater difference exists between the composition the atmosphere as regards oxygen and nitrogen in different latitudes (some few spec cases excepted), than is found in the same place at different times.

Frankland (Chem. Soc. Qu. J. xiii. 22) has lately determined the composition air collected by himself at different elevations on Mont Blanc, viz. at the Gran Mulets, at the summit, and at Chamounix. The conclusion which Frankland dra from his experimental numbers is, that as far as the nitrogen and oxygen are co cerned, the composition of these samples of air falls within the limits of variati noticed by former experimenters.

That the air is a mechanical mixture and not a chemical combination of oxyg and nitrogen is seen from the following facts: 1. The amounts of oxygen and nitrog in the air do not present any simple relation to the combining proportions of the

are moreover variable. 2. On mixing oxygen and nitrogen gases in the
which they occur in air, no contraction or evolution of heat is observed, and
ts in every way as air. 3. When air is dissolved in water, the proportion
xygen and nitrogen in the dissolved air is quite different from that in
d air, this difference occurring in strict accordance with the laws of the
ases in liquids (see GASES, ABSORPTION OF). When water is saturated with
perature below 30° C., 100 volumes of the dissolved air contain 34·19 vols.
65·09 vols. of nitrogen, whilst the undissolved air contains 21·1 per cent.
l 78·9 per cent. of nitrogen. Were the air a chemical combination of
trogen, such a separation by solution would be impossible.

constituents of the atmosphere, viz. the aqueous vapour, carbonic acid,
decomposing organic matter, alter in amount at various times and in
s, much more considerably than the oxygen and nitrogen.

lity of the air is affected by many circumstances, such as temperature,
masses of water, and configuration of the land over which it lies. The
eous vapour which any volume of air can take up depends entirely upon
ure of the air, and is represented by the tension and corresponding
vapour of water in vacuo for that temperature; thus at 10° C. the
ueous vapour is 9·47 mm. of mercury, and the corresponding density
r 1 cubic metre of air at 10° C. is saturated when it contains 9·74 grms.
e form of vapour. It seldom happens, however, that the air contains its
ntity of moisture, and the amount varies extremely with the conditions
ned; thus, on the coast of the Red Sea, during a simoon, the air was
in only $\frac{1}{12}$ part of the aqueous vapour required to saturate it, whilst in
ate, the air is often saturated with watery vapour. The following table
ative humidity, *i. e.* the existing percentage on the saturating quantity,
ämtz in Halle, as a mean of several years' observations:

March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
76·4	71·4	69·1	69·7	66·5	61·0	72·8	78·9	85·3	86·2

e that in Halle the air is most humid in December and driest in

ination of the aqueous vapour contained in the atmosphere may be
by leading a known volume of air through weighed tubes containing
pic substance, as sulphuric acid or chloride of calcium, or by means
rs of various construction, for the description of which the article
must be consulted.

nic acid or anhydride contained in the air varies also considerably in
h by no means to so large an extent as the aqueous vapour. Many methods
for ascertaining the quantity of carbonic acid present in the atmosphere.
ain method is to absorb the carbonic acid from a known volume of air by
r, freed from aqueous vapour and ammonia, through weighed tubes con-
c potash. Saussure (Pogg. Ann. xix. 391), Brunner (Pogg. Ann.
Pettenkofer (Chem. Soc. Qu. J. x. p. 292), Smith (Chem. Soc. Qu.
and Frankland (Chem. Soc. Qu. J. xiii. 27), have all proposed different
he explanation of which we must refer to the original papers.

numerous observations made by Saussure, Brunner, Lewy, and others, it
ir in the open country contains quantities of carbonic acid varying from
nes in 10,000 of air. As an average number, it has been found that
00 represent the usual composition of the air as regards carbonic acid.
eculiar cases, a much larger proportion of carbonic acid has been found
Lewy in S. America at Bogota); but these abnormal results are ex-
al circumstances, as neighbouring volcanic emanations or burning forests.
ted above the ocean showed a small variation in carbonic acid between
; that collected in the day contained 5·4, whilst that collected during
ained 3·3 carbonic acid in 10,000 volumes of air. This observation is
ed for by the increase of the coefficients of absorption with the diminution
e occurring during the night. Air above the land also slightly changes
carbonic acid at various seasons of the year and times of the day, in
pon different meteorological alterations, but as yet experiment has not
ature of this dependence. At a certain elevation above the earth's sur-
ccording to Saussure and Schlagentweit, contains more carbonic acid than

is found in the lower belts of the atmosphere; this increase, which however i
not large, probably arises from the decrease of vegetation in the higher atmospheri
regions. In the air of crowded towns or of closed inhabited spaces (such as dwelling
rooms, &c.), the carbonic acid often rises to ten times the normal quantity, owing to in
efficient ventilation.

Although the relative amount of 4 vols. of carbonic acid in 10,000 vols. of air ap
pears to be a very small one, yet the absolute quantity of carbon thus contained in th
atmosphere is very large, exceeding indeed all that is contained on the earth's surface i
the solid form, in the bodies of plants and animals, and that found under the earth'
solid crust in the coal formations. The question of change in the composition of th
earth's atmosphere as regards carbonic acid is one of vital interest to all forms o
terrestrial life: for whilst forming the staple nutriment of the vegetable world, car
bonic acid, when present in certain quantities, acts as a violent poison on the highe
orders of animal life; nor is the limit at which this gas begins to be hurtful to th
animal, very far removed from the quantity which at present exists in the atmo
sphere: for we find that Leblanc and Péclet assign a limit of five in 1000 (ten time
the normal quantity), whilst Reid and Arnott give a much lower limit to the non
injurious effect of this gas. Whether the atmosphere is now slowly undergoing, o
has in past ages undergone, any perceptible change in the amount of its carbonic aci
is a question to which, owing to the absence of certain and accurate data, we are as ye
unable to give any very satisfactory answer. We do, however, know that there are
great number of causes continually at work, some of which tend to increase the amoun
of atmospheric carbonic acid, whilst there are others which tend to effect a diminutio
in this constituent. Whether the resultant of these various counteracting influences i
such as to keep, during future ages, the carbonic acid exactly at the present amount,
is, with our present knowledge, impossible to say; but from the remarks which follow
it will be seen that if any alteration occur, it must proceed with extreme slowness.

The principal causes which tend to increase the atmospheric carbonic acid are
(1) The respiration of animals. (2) Combustion of vegetable carbonised materia
(3) Exhalations of carbonic acid caused by volcanic and other intra-terrestri
agencies. It would appear that the quantity of carbonic acid escaping from volcan
vents, mineral springs, and other inorganic sources into the atmosphere is muc
larger than that produced by the two causes first named. According to the calcul
tions of Poggendorff (naturally but very rude approximations to the truth), it seem
that, taking the amount of carbonic acid evolved by volcanic action to be ten time
larger than that given off by every kind of combustion of carbonised material, th
quantity of carbonic acid at present contained in the atmosphere would be doubled i
386 years, supposing, of course, that no causes of diminution of were acting. Th
such causes of diminution are, however, continually at work we know. They consi
mainly in (1) the decomposition of carbonic acid, *i. e.* reduction of carbon and regener
tion of oxygen, which living vegetables effect in sunlight. (2) The fixation of carbon
acid as carbonate of lime by the vital action of certain animalculæ, giving rise
coral reefs and islands, and the whole of the vast limestone deposits. (3) Th
fixation of carbonic acid by inorganic chemical processes.

The immense extent to which these actions, particularly the second one, have go
and are still going on, appears to justify the opinion that if any change in the amou
of the atmospheric carbonic acid occur at all, it is more probably a diminution tha
an increase. Any conclusions which we can draw from geological facts, seem rather
support this opinion: for it is more likely that the air contained a larger amount
carbonic acid during the deposition of the enormous carboniferous system when th
vegetation must have been so luxuriant and profuse, and when few, if any, air-breathin
animals existed, than less than at present. Still, we have no right positively
assume that the air at the time of the deposition of the coal and limestone containe
more carbonic acid than now: for we know nothing of the length of time during whic
these formations were in progress.

From the foregoing remarks, it is seen that a continual circulation of the atmospher
carbon takes place; the animal gives off the waste portion of its body mainly as ca
bonic acid, and thus deteriorates the atmosphere, which would soon become unfit f
his further use, if the vegetable world did not absorb the poisonous gas, at onc
retaining the carbon in the solid form, fit for the subsequent nourishment of the anim
and exhaling the oxygen wherewith the higher organism again removes his spe
materials.

Having described the causes effecting possible variation of the atmospheric carbon
acid, it is almost needless to consider any change which the oxygen may undergo, f
the atmosphere becomes unfit for the sustenance of animal life from the presence of
small quantity of carbonic acid, long before the oxygen is materially diminished. I
however, the carbonic acid is slowly decreasing, it may be interesting to inquire ho

ur supply of oxygen will last us. Such a speculation has been answered, as satis-
ily as the circumstances admit of, by Dumas and Boussingault. These chemists
ated that if the whole of the earth's atmosphere were put into a balloon and sus-
d from one end of a balance, it would require 581,000 cubes of copper, each having
of 1 kilometre (1093 English yards) in length, to be suspended at the other end
alise the balance. Of this total weight, the oxygen would be represented by
)0 cubes. Assuming, from the best data, that a man consumes a kilogramme of
n per day, taking the population of the earth to be 1000 millions, and supposing
he oxygen taken up by animals and by putrefactive processes is four times as large
at consumed by human beings, and supposing further, that the oxygen given off
nts only covers the expenditure of oxygen effected by other causes not mentioned,
ears, even in this exaggerated case, that an amount of oxygen three times as large
t consumed in one century by the whole number of animals existing on the earth,
resented by 15 or 16 of the copper cubes, each having a side of 1 kilometre in
, or the alteration effected in a century is less than $\frac{1}{8000}$ of the total quantity of oxy-
nd is therefore altogether inappreciable by our most exact determinative methods.
)umas and Boussingault (1841) Ann. Ch. Phys. [3] iii. 257, 288.)

regards the **ammonia** and the **organic impurities** contained in the atmo-
, we still labour under the disadvantage of insufficient experimental data. The
difficulty in the estimation of these constituents, lies in the very minute quantities
are contained in the atmosphere. This difficulty is seen when we compare some
statements put forward of the amount of atmospheric ammonia; thus **Horsford**
Ch. Pharm. lxxiv. 243), found in 1 million parts of air, 47·6 parts of ammonia,
Bineau (Ann. Ch. Phys. xlii. p. 462) found in the same quantity of air, from
o 0·1 part of ammonia. Between these extremes, we have numerous experiments
ich every variation in the quantity of atmospheric ammonia has been found. Al-
h, from the great differences in the numerical results (maximum 135; minimum
rts of carbonate of ammonia), probably arising, partly from errors of analysis and
from real variations in the contained quantity, it is impossible to fix upon any
er as giving the average composition, still it is certain that the atmosphere
s contains ammoniacal salts, and that rain (the first portions more than the latter
ns), hail, snow, and dew, all contain appreciable quantities of ammonia.

e atmospheric ammonia plays a very important part in vegetation: for it is mainly
altogether, from the ammoniacal salts contained in the air, that plants obtain
itrogen which they require for the formation of seed and other essential parts of
structure. Whether plants are at all able to assimilate the free nitrogen of the
phere, must, in spite of the numerous researches on the subject, be considered
ful. George Ville has for some time asserted, founding his assertion on a large
er of elaborate experiments, that plants can absorb and assimilate the free atmo-
ic nitrogen. Boussingault, on the contrary, from his own extensive investigations,
Ville's conclusions, affirming that it is from nitrogenous compounds alone that
s can assimilate the nitrogen. The commission of the French Academy, which
deputed to examine the question under the direction of Chevreul, reported in
s favour, although some doubt as to the estimation of the ammonia contained in
istilled water used, was expressed. Still more lately Lawes, Gilbert, and Pugh,
investigated the subject with great care, and find that plants growing in an
phere and on a soil free from ammonia or combined nitrogen in other forms,
t contain more nitrogen than the seeds from which they grow. In the state of
tainty in which such contradictory statements leave us, we may, however, be certain
e fact in which all the experiments agree, namely, that whether or not plants can
ilate small quantities of free nitrogen, it appears that plants growing in air
ctly free from ammonia, do not flourish to anything like the same extent as plants
in an ammoniacal atmosphere.

ncerning the remaining constituents, and especially the organic putrescent matters,
resent knowledge is even less satisfactory or positive than is the case with the
onia. Within a very recent period, we were unacquainted with any method for
mining the presence of organic putrescent matters; and even the very important
ingenious method lately proposed by Dr. **R. Angus Smith** (Chem. Soc. Qu. J.
196) requires much extension and general application before we can arrive at
owledge of the exact qualitative distribution of the organic impurities. Smith's
od (for the details of which we must refer to the paper), depends upon the
ing action which solid, liquid or gaseous organic putrescent matter effects on per-
anate of potassium. The strength of the test-solution is determined by adding
a solution of sugar of known composition, until the colour of the permanganate
ins permanent; and the same reaction performed with the air under examination,
s the quantity of contained organic matter. In this way, Smith has detected great

differences between the air of various localities. The air from high country ground was found to contain 1 grain of organic matter in 200,000 cubic inches of air, whilst the air from a cesspool contained the same quantity of organic matter in 60 cubic inches of air. In a sanitary, as well as in a purely scientific point of view, it is difficult to over-estimate the importance of this simple method for determining the organic impurities which air contains; and if future research confirm its applicability to all cases, it will prove an invaluable instrument in the hands of the physician and the sanitary reformer.

Besides the constituents already mentioned, air contains minute quantities of nitrates, hydrocarbons, sulphurous and sulphuric acids, and according to some chemists, iodine, but this has been lately denied. Ozone also occurs in the atmo-sphere in very small amounts, varying, however, extremely with the situation and meteorological conditions of the place. (See OZONE.)

The atmosphere of the ocean, as well as of the masses of fresh water occurring on the earth's surface, is subject to the same changes from the existence of animal and vegetable life, as the earth's gaseous atmosphere. The relative proportion between the gases dissolved in the water is fixed in accordance with the law of absorption, and many important and interesting conclusions, such as the relative increase of dissolv oxygen, or diminution of temperature, enabling mammalia to live in the polar but not in the tropical seas, can be drawn from an application of these laws to the atmosphere of the sea. The equilibrium between the constituents of the dissolved atmosphere kept up by animal and vegetable life, is well illustrated by the vivaria now so common, which were first introduced by Mr. Warington.

The air of towns and close-inhabited spaces, becomes, as has been stated, often overcharged with carbonic acid and other impurities. The amount of carbonic acid present in dwelling-rooms, &c., has been made the subject of experiment by Leblan (Ann. Ch. Phys. [3] v. 223; xxvii. 373), Pettenkofer (Chem. Soc. Qu. J. x. 292) Roscoe (Chem. Soc. Qu. J. x.); and Smith (Chem. Soc. Qu. J. xi. 196). The main results may be stated to be: (1) that in rooms which are not thoroughly ventilated, the amount of carbonic acid may rise from 1 to 7 volumes in 1000 of air; (2) that in wel ventilated rooms, the amount of carbonic acid should not rise above 0·8 in 1000 (3) that in ordinary dwellings, or even in school- or barrack-rooms, the carbonic acid i diffused uniformly throughout the space, in whatever parts of the room the exit fo deteriorated air is placed, though in the exaggerated case of crowded theatres, th air at the highest part of the building was found to contain more carbonic acid than the air at the level of the stage. For other interesting details, we must refer to th original papers, or to the article on VENTILATION. H. E. R.

ATOMIC VOLUME. *Specific volume; Equivalent volume; Molecular volum* — The atomic or specific volume of a body is the space occupied by a quantity o it proportional to its atomic weight, and is therefore expressed by the quotient of th atomic weight divided by the weight of a unit-volume, that is by the specific gravity

$$\text{Atomic volume} = \frac{\text{atomic weight}}{\text{specific gravity}}$$

It must not, however be supposed that the atomic volumes represent the relativ volumes of the actual material atoms of different bodies. For, regarding any sub stance, solid, liquid, or gaseous, as an aggregate of material particles capable o moving amongst themselves, it is impossible to suppose these particles to be in actua contact and to fill up the entire volume of the body; we must suppose them to b separated by certain intervals: consequently the specific gravity, and therefore als the specific volume of the body, will depend, partly on the relative weights of thes atoms, partly on the number of them contained in a given space, and therefore on th magnitude of the interstitial spaces. Unless, therefore, the spaces are either infinitel small in comparison with the magnitude of the atoms themselves, or bear the sam proportion thereto in all bodies, it is impossible to determine the relative volumes o the actual material atoms: for we have no means of ascertaining the proportio between the size of the atoms and of the intervening spaces in each particular case The atomic volume of bodies must therefore be understood, as the spaces occupied b aggregates of atoms (including the interstitial spaces), whose weights are proportiona to the atomic weights of the bodies.

As the atomic weights, or multiples thereof, represent the proportions in whic bodies combine by weight, so likewise do the atomic volumes or multiples thereo indicate the proportions in which they unite by volume, thus: the atomic volume o iodine being $\frac{127}{4\cdot95} = 25\cdot7$, and that of silver $= \frac{108}{10\cdot4} = 10\cdot2$, we infer that 25·7 vol iodine unite with 10·2 vols. silver to form iodide of silver, AgI.

numbers representing the atomic volumes of bodies vary according to the units
nic weight and specific gravity chosen, and according to the particular values
ed to the atomic weights. Thus, if the atomic weight of hydrogen be equal to 1,
chlorine = 35·5, and of sulphur = 32, the atomic weight of hydrochloric acid
will be 36·5, and that of sulphydric acid (H^2S) = 34. Now the specific gravity
rochloric acid gas referred to air as unity is 1·264, and that of sulphydric acid
7. Hence we have:

$$\text{Atomic volume of HCl} = \frac{36{\cdot}5}{1{\cdot}264} = 14{\cdot}44$$

$$\text{,,}\quad\text{,,}\qquad H^2S = \frac{34}{1{\cdot}177} = 14{\cdot}44$$

the other hand, we adopt hydrogen as the standard of specific gravity for gases,
f hydrochloric acid is 18·25, and that of sulphydric acid is 17, in each case
e atomic weight. On this hypothesis, therefore, the atomic volumes of both
re expressed by the number 2. Again, if common ether be represented by the
a $C^4H^{10}O$ [C = 12, H = 1, O = 16], its atomic weight is 74; and, its specific
in the gaseous state being 37 (referred to hydrogen), its atomic volume in
ate is $\frac{74}{37} = 2$, and in the liquid state (specific gravity at 0° referred to water),
nic volume is $\frac{74}{0{\cdot}737} = 100{\cdot}41$. But if ether be represented by the formula
[$C = 6$, $H = 1$, $O = 8$], then its atomic volume in the gaseous state will be
1, and in the liquid state $\frac{37}{0{\cdot}737} = 50{\cdot}205$. The atomic volumes of gases and
s are calculated from the specific gravities referred either to hydrogen or to
heric air; those of solids and liquids from the specific gravities referred to water
y.

Atomic Volumes of Gases.

rding to the system of atomic weights adopted in this work, equal volumes of
nt elementary gases are supposed to contain, for the most part, equal numbers
ns of their respective elements, so that the atomic weight of each body in the
s state is the weight of a volume of the gas equal to that of a quantity of hydro-
hose weight is taken as unity; in other words, the atomic weights of the simple
re expressed by the same numbers as their specific gravities referred to hydro-
unity. This is sometimes expressed by saying that an atom of each elementary
cupies *one* volume. The only exceptions to this law are presented by phosphorus
senic, whose densities in the gaseous state are double of what they should be if
llowed the law; and by selenium and tellurium, whose vapour-densities have not
en ascertained with certainty. Sulphur-vapour was formerly supposed to have
ity three times as great as that which the general law just stated requires, but
experiments have shown that it conforms to the general law.*

atoms or molecules of compound bodies in the gaseous state occupy, for the
art, *twice* the volume of an atom of hydrogen or other simple gas; in other
the number of molecules of a compound gas contained in a given space is half
mber of atoms of hydrogen which would be included in that same space. Con-
tly, the specific gravity of a compound gas or vapour referred to hydrogen as
is equal to half the atomic weight. Thus, the atomic weight of hydrochloric
HCl) is 36·5, and its specific gravity referred to hydrogen is 18·25; the atomic
of ammonia (NH^3) is 17, and its specific gravity referred to hydrogen is 8·5.
he further development of this law, and for certain exceptions to it, real and
nt, see the article ATOMIC WEIGHTS.)

mode of stating these laws of gaseous atomic volume, must of course be modified
ing to the system of atomic weights chosen. On that which has hitherto been
enerally adopted ($H = 1$, $O = 8$, $S = 16$, &c.), some of the elementary gases,
lorine, iodine, bromine, nitrogen, and mercury are supposed to have atomic
es equal to that of hydrogen, while oxygen, sulphur, phosphorus, and arsenic
tomic volumes only half as great. The former are generally called *two-volume*
and the latter *one-volume* gases, the volume of oxygen being taken as the unit.
same system, the molecules of most compound bodies in the gaseous state are
occupy *four* volumes.

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ording to the atomic weights now adopted, the vapour-densities of mercury and cadmium are
f their respective atomic weights, that of mercury being 100 and that of cadmium 56.

Atomic Volumes of Liquids and Solids.

1. Of Elementary Bodies. The following table contains the atomic volumes those solid and liquid elements whose densities have been determined with accura The numbers in the third column are the quotients of the atomic weights divided by t specific gravities referred to water as unity:

Substance.	Atomic weight.*	Atomic volume.	Specific gravity (water = 1).
Aluminium . .	13·75	5·3	2·5—2·67, Wöhler; 2·67, Deville.
Antimony . .	120·3	17·9	6·72, Marchand and Scheerer; Kopp.
Arsenic . . .	75	13·3	5·63, Karsten; 5·67, Herapath.
Bismuth . .	210	21·2	9·80, Marchand and Scheerer; 9·78, Kopp.
Bromine . .	80	25·8	*Liquid:* 3·19, Pierre; 2·99, Löwig.
Cadmium . .	56	6·5	8·69, Stromeyer; 8·45, Kopp.
Calcium . .	20	12·6	1·58, Bunsen.
Carbon . . .	12	3·4 5·2	*Diamond:* 3·52, Brisson. *Graphite:* 2·32, Karsten; 2·27, Regnault.
Chlorine . .	35·5	26·7	*Liquid:* 1·33, Faraday.
Chromium . .	26·2	3·8	7·01, Bunsen and Frankland.
Cobalt . . .	29·5	3·5	8·49, Brunner; 8·51, Berzelius.
Copper . . .	31·7	3·6	8·95, Marchand and Scheerer; 8·93, Kopp.
Glucinum . .	4·7	2·2	2·1, Debray.
Gold . . .	196	10·2	19·34, G. Rose; 19·26, Brisson.
Iodine . . .	127	25·7	4·95, Gay-Lussac.
Iridium . . .	99	4·5	21·80, Hare.
Iron . . .	28	3·6	7·84, Broling; 7·79, Karsten
Lead . . .	103·6	9·2	11·39, Karsten; 11·33, Kopp.
Lithium . .	7	11·9	0·59, Bunsen.
Magnesium . .	12	6·9	1·74, Bunsen; 1·70. Kopp.
Manganese . .	27·6	3·5	8·03, Bachmann; 8·01, John.
Mercury . .	100	7·4	*Liquid:* 13·60, Regnault, Kopp.
Molybdenum . .	46	5·3	8·62—8·64, Buchholz.
Nickel . . .	29·5	3·4	8·60, Brunner; 8·82, Tupputi.
Palladium . .	53	4·6	11·80, Wollaston.
Phosphorus . .	31	16·8 15·8	*Yellow:* 1·84, Schrötter; 1·83, Kopp. *Red:* 1·96, Schrötter.
Platinum . .	99	4·6	21·5, Wollaston, Berzelius.
Potassium . .	39·2	45·6	0·86, Gay-Lussac and Thenard.
Rhodium . .	52	4·7	11·0, Wollaston; 11·2, Cloud.
Selenium . .	79	18·4 16·4	*Amorphous:* 4·28, Schaffgotsch. *Granular:* 4·80, Schaffgotsch.
Silicon . . .	28	11·2	*Graphitoïdal:* 2·49, Wöhler.
Silver . . .	108	10·2	10·4, Karsten, 10·57, G. Rose.
Sodium . . .	23	23·7	0·97, Gay-Lussac and Thenard.
Strontium . .	43·8	17·2	2·54, Bunsen.
Sulphur . .	32	15·2 16·2	*Trimetric:* 2·07, Marchand and Scheerer, K *Monoclinic:* 1·98, Marchand and Scheerer.
Tellurium . .	128	20·6	6·24, Berzelius; 6·18, Löwe.
Tin . . .	118	16·2	7·29, Karsten; 7·30, Kopp.
Tungsten . .	92	5·3	17·2, Allen and Aiken; 17·5—18·3, Wöhler
Uranium . .	60	3·3	18·4, Péligot.
Zinc . . .	32·5	4·6	7·13, Kopp; 7·1—7·2, Bolley.

The numbers in the third column of this table, do not exhibit the simplicity o lation which exists between the atomic volumes of gaseous bodies. There are, ind several causes which interfere with the existence, or at least with the observatio such simple relations between the atomic volumes of solid and liquid elements. the first place, the densities of three of them, viz. mercury, bromine, and chlorine such as belong to them in the liquid state, whereas the densities assigned to all others have been determined in the solid state. In solids, moreover, the densit greatly affected by the state of aggregation, whether crystalline or amorphous, an dimorphous bodies, each form has a density peculiar to itself. Further, as solids s are variously affected by heat, each having a peculiar rate of expansion, and ate being different at different temperatures, it is not to be expected that their c volumes should exhibit simple relations, unless they are compared at tempes at which they are similarly affected by heat. Even gases are found to exhibit mal atomic volumes if compared at temperatures too near the points at which ass into the liquid state. In liquids, the simplest relations of atomic volume are at those temperatures for which the tensions of the vapours are equal (Kopp); n solids, the melting points are most probably the comparable temperatures. the specific gravities of most of the solid elements in the preceding table, have determined at mean temperatures (as at 15°·5 C.), which, in the case of potassium, m, phosphorus, and a few others, do not differ greatly from the melting points, n other cases, as with gold, platinum, iron, &c., are removed from the melting s by very long intervals. In spite, however, of these causes of divergence, the c volumes of certain analogous elements are very nearly equal to each other: viz. of selenium and sulphur; of chromium, iron, cobalt, copper, manganese and l; of molybdenum and tungsten; of iridium, platinum, palladium and rhodium; f gold and silver.

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* The atomic weights here given and used throughout this article are the same as those in the on pages 464, 465. When the atomic weights of the metals, Al, Ca, Pb, &c. are doubled, the c sponding atomic volumes will also be doubled.

Of Liquid Compounds. The relations between the atomic volumes of liquids, been investigated chiefly by H. Kopp (Ann. Ch. Pharm. xcvi. 153, 303, c. 19). tomic volumes of liquids, as already observed, are comparable only at temperatures hich the tensions of their vapours are equal, as at the boiling points. If the c weights are compared with the densities at equal temperatures, no regular res can be perceived; but when the same comparison is made at the boiling points respective liquids, several remarkable laws become apparent. The density of a at its boiling point cannot be ascertained by direct experiment; but when the y at any one point, say at 15·5° C., has been ascertained, and the rate of exon is also known, the density at the boiling point may be calculated. (See NSION.)

ble A. contains Kopp's determinations of the atomic volumes of several liquids ining carbon, hydrogen, and oxygen, at their boiling points. The atomic weights ose of the hydrogen scale. The *calculated* atomic volumes in the fourth column etermined by a method to be presently described; the *observed* atomic volumes e quotients of the atomic weights divided by the specific gravities at the boiling ed to water as unity.

Table A.

Atomic Volumes of Liquids containing Carbon, Hydrogen, and Oxygen.

Substance.	Formula.	Atomic Weight.	Atomic Volume at the Boiling Point.	
			Calculated.	Observed.
Benzene	C^6H^6	78	99·0	96·0... 99·7 at 80° C.
Cymene	$C^{10}H^{14}$	134	187·0	183·5...185·2 „ 175
Naphthalin . . .	$C^{10}H^8$	128	154·0	149·2 . . „ 218
Aldehyde	C^2H^4O	44	56·2	56·0... 56·9 „ 21
Valeraldehyde . .	$C^5H^{10}O$	86	122·2	117·3...120·3 „ 101
Bitter almond oil . .	C^7H^6O	106	122·2	118·4 . . „ 179
Cuminol . . .	$C^{10}H^6O$	148	188·2	189·2 . . „ 236
Tetryl	C^8H^{18}	114	187·0	184·5...186·8 „ 108
Acetone	C^3H^6O	58	78·2	77·3... 77·6 „ 56
Water	H^2O	18	18·8	18·8 . . „ 100
Wood-spirit . . .	CH^4O	32	40·8	41·9... 42·2 „ 59
Alcohol	C^2H^6O	46	62·8	61·8... 62·5 „ 78
Amylic alcohol . .	$C^5H^{12}O$	88	128·8	123·6...124·4 „ 135
Phenylic alcohol . .	C^6H^6O	94	106·8	103·6...104·0 „ 194
Benzylic alcohol . .	C^7H^8O	108	128·8	123·7 . . „ 213
Formic acid . . .	CH^2O^2	46	42·0	40·9... 41·8 „ 99
Acetic acid . . .	$C^2H^4O^2$	60	64·0	63·5... 63·8 „ 118
Propionic acid . .	$C^3H^6O^2$	74	86·0	85·4 . . „ 137
Butyric acid . . .	$C^4H^8O^2$	88	108·0	106·4...107·8 „ 156
Valerianic acid . .	$C^5H^{10}O^2$	102	130·0	130·2...131·2 „ 175
Benzoic acid . . .	$C^7H^6O^2$	122	130·0	126·9 . . „ 253

TABLE A (*continued*).

	Substance.	Formula.	Atomic Weight.	Atomic Volume at the Boiling Point.	
				Calculated.	Observed.
Type HH.O.	Ethylic ether	$C^4H^{10}O$	74	106·8	105·6...106·4 at 34 °C
	Acetic anhydride	$C^4H^6O^3$	102	109·2	109·9...110·1 „ 138
	Formate of methyl	$C^2H^4O^2$	60	64·0	63·4 . . „ 36
	Acetate of methyl	$C^3H^6O^2$	74	86·0	83·7... 85·8 „ 55
	Formate of ethyl	$C^3H^6O^2$	74	86·0	84·9... 85·7 „ 55
	Acetate of ethyl	$C^4H^8O^2$	88	108·0	107·4...107·8 „ 74
	Butyrate of methyl	$C^5H^{10}O^2$	102	130·0	125·7...127·3 „ 93
	Propionate of ethyl	$C^5H^{10}O^2$	102	130·0	125·8 . . „ 93
	Valerate of methyl	$C^6H^{12}O^2$	116	152·0	148·7...149·6 „ 112
	Butyrate of ethyl	$C^6H^{12}O^2$	116	152·0	149·1...149·4 „ 112
	Acetate of tetryl	$C^6H^{12}O^2$	116	152·0	149·3 . . „ 112
	Formate of amyl	$C^6H^{12}O^2$	116	152·0	149·4...150·2 „ 112
	Valerate of ethyl	$C^7H^{14}O^2$	130	174·0	173·5...173·6 „ 131
	Acetate of amyl	$C^7H^{14}O^2$	130	174·0	173·3...175·5 „ 131
	Valerate of amyl	$C^{10}H^{20}O^2$	172	240·0	244·1 . . „ 188
	Benzoate of methyl	$C^8H^8O^2$	136	152·0	148·5...150·3 „ 190
	Benzoate of ethyl	$C^9H^{10}O^2$	150	174·0	172·4...174·8 „ 209
	Benzoate of amyl	$C^{12}H^{16}O^2$	192	240·0	247·7 . . „ 266
	Cinnamate of ethyl	$C^{11}H^{12}O^2$	176	207·0	211·3 . . „ 260
Type 2(HH.O).	Acid salicylate of methyl	$C^8H^8O^3$	152	159·8	156·2...157·0 „ 223
	Carbonate of ethyl	$C^5H^{10}O^3$	118	137·8	138·8...139·4 „ 126
	Oxalate of methyl	$C^4H^6O^4$	118	117·0	116·3 . . „ 162
	Oxalate of ethyl	$C^6H^{10}O^4$	146	161·0	166·8...167·1 „ 186
	Succinate of ethyl	$C^8H^{14}O^4$	174	205·0	209·0 . . „ 217

A comparison of the numbers in this table, leads to the following results: —

1. *Differences of atomic volume are in numerous instances proportional to the d ferences between the corresponding chemical formulæ.* — Thus, liquids whose formu differ by $n \,.\, CH^2$, differ in atomic volume by $n \,.\, 22$; for example, the atomic volumes formate of methyl, $C^2H^4O^2$, and butyrate of ethyl, $C^6H^{12}O^2$, differ by nearly 4 × Acetate of ethyl, $C^4H^8O^2$, and butyrate of methyl, $C^5H^{10}O^2$. whose formulæ differ CH^2, differ in atomic volume by nearly 22. The same law holds good with respect liquids containing sulphur, chlorine, iodine, bromine, and nitrogen (see Tables B, D). Again, by comparing the atomic volumes of analogous chlorine and bromi compounds, it is found that the substitution of 1, 2, or 3 atoms of bromine for equivalent quantity of chlorine, increases the atomic volume of a compound by on twice, or three times 5. This will be seen by comparing the atomic volumes of P and PCl^3; C^2H^5Br and C^2H^5Cl, &c. (Table C.)

2. *Isomeric liquids belonging to the same chemical type have equal atomic volumes.* The atomic volume of acetic acid, $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O$ is between 63·5 and 63·8; that formate of methyl, $\left.\begin{matrix}CHO\\CH^3\end{matrix}\right\}O$ is 63·4; the atomic volume of butyric acid, $\left.\begin{matrix}C^4H^7O\\H\end{matrix}\right\}O$ between 106·4 and 107·8; that of acetate of ethyl, $\left.\begin{matrix}C^2H^3O\\C^2H^5\end{matrix}\right\}O$ is between 107·4 107·8.

3. *In liquids of the same chemical type, the replacement of hydrogen by an equival quantity of oxygen* (that is to say, of 1 pt. of hydrogen by 8 pts of oxygen), *makes a slight alteration in the atomic volume.*—This may be seen by comparing the ato volumes of alcohol, C^2H^6O, and acetic acid, $C^2H^4O^2$; of ether, $C^4H^{10}O$, acetate of eth $C^4H^8O^2$, and anhydrous acetic acid, $C^4H^6O^3$; of cymene, $C^{10}H^{14}$, and cuminol, $C^{10}H^{1}$ The alteration caused by the substitution of O for H^2 is always an increase.

4. *In liquids of the same chemical type, the replacement of* 2 *at.* H *by* 1 *at* C (1 by weight of hydrogen by 6 parts of carbon) *makes no alteration in the atomic volu* —Such, for example, is the case with benzoate of ethyl, $C^9H^{10}O^2$, and valerate ethyl, $C^7H^{14}O^2$, and with the corresponding benzoates and valerates in general; a

bitter-almond oil, C^7H^6O, and valeraldehyde, $C^5H^{10}O$; also with phenylic ol, C^6H^6O, and vinic ether, $C^4H^{10}O$.

liquids belonging to different types, the same relations are not found to hold Moreover, the types within which these relations are observed, are precisely of Gerhardt's classification (see CLASSIFICATION). Further, when liquid comls are represented by rational formulæ founded on these types, their atomic nes may be calculated from certain fundamental values of the atomic volumes of lements, on the supposition that the atomic volume of a liquid compound is equal sum of the atomic volumes of its constituent elements. In this manner the ated atomic volumes in the fourth columns of tables A, B, C, D are determined. st be understood however that these values are based upon somewhat doubtful nptions respecting the atomic volumes of the elements, and are regarded by Kopp y as approximations to the truth.

ce the addition of CH^2 to a compound increases the atomic volume by 22, this er may be taken to represent the atomic volume of CH^2; moreover, since C take the place of H^2 in combination, without altering the atomic volume of the ound, it follows that the atomic volume of C must be equal to that of H^2; and fore the atomic volume of $C = \frac{22}{2} = 11$, and that of H^2 also equal to 11, or that $= 5·5$. Further, as the substitution of O for H^2 produces a slight increase in tomic volume of a compound, the atomic volume of O must be rather greater 11; and it is found that, by assuming the atomic volume of O, when it takes of H^2 (that is to say, in a radicle, as when acetyl, C^2H^3O, is formed from ethyl,), to be equal to 12·2, results are obtained agreeing very nearly with those of vation. But when oxygen occupies the position which it has in water, $\left.\begin{matrix}H\\H\end{matrix}\right.O$, its c volume is smaller. The specific gravity of water at the boiling point is 9; hence its atomic volume at that temperature is $\frac{18}{0·9579} = 18·8$; now the ms of hydrogen occupy a space equal to 11; hence the volume of the oxygen . The same value of the atomic volume substituted for O in the formula of the al compounds belonging to the water-type, in which it occupies a similar place, is to say, outside the radicle, gives results agreeing nearly with observation. a given quantity of a substance should occupy different spaces, under different mstances, is a fact easily explained, when it is remembered that the particles of dy cannot be supposed to be in absolute contact, but are separated by certain s, which, increase or diminish according to the temperature of the body, and ding as it is in the solid, liquid, or gaseous state.

om these values of the atomic volumes of the elements, carbon, hydrogen, and en; viz.

Atomic volume of C . . . . = 11
" " H . . . . = 5·5
" " O (within the radicle) . . . . . = 12·2
" " O (without the radicle) . . . . . = 7·8

alculated values of the atomic volumes of liquids, in the fourth column of Table e deduced. The method of calculation may be understood from the following ples:

Benzene, $C^6H^6 = C^6H^5.H$.

Atomic volume of C^6 . . . . = 66
" " H^6 . . . . = 33
" " benzene . . . . = 99

Aldehyde, $C^2H^4O = C^2H^3O.H$.

Atomic volume of C^2 . . . . = 22
" " H^4 . . . . = 22
" " O (within the radicle) . . . = 12·2
" " aldehyde . . . . = 56·2

Alcohol, $C^2H^6O = \left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O$.

Atomic volume of C^2 . . . . = 22
" " H^6 . . . . = 33
" " O (without the radicle) . . . = 7·8
" " alcohol . . . . = 62·8

Acetic acid, $C^2H^4O^2 = \left.\begin{matrix}H\\C^2H^3O\end{matrix}\right\}O$.

Atomic volume of C^2 . . . = 22
„ „ H^4 . . . = 22
„ „ O (within the radicle) . . . = 12·2
„ „ O (without the radicle) . . . = 7·8
„ „ acetic acid . . . = 64·0

Acetic anhydride $C^4H^6O^3 = \left.\begin{matrix}C^2H^3O\\C^2H^3O\end{matrix}\right\}O$.

Atomic volume of C^4 . . . = 44
„ „ H^6 . . . = 33
„ „ O^2 (within the radicle) . . . = 24·4
„ „ O (without the radicle) . . . = 7·8
„ „ acetic anhydride . . . = 109·2

Oxalate of methyl, $C^4H^6O^4 = \left.\begin{matrix}C^2O^2\\(CH^3)^2\end{matrix}\right\}O^2$.

Atomic volume of C^4 . . . = 44
„ „ H^6 . . . = 33
„ „ O^2 (within the radicle) . . . = 24·4
„ „ O^2 (without the (radicle) . . . = 15·0
„ „ oxalate of methyl . . . = 117·0

Liquids containing Sulphur.—Sulphur enters into combination in various wa sometimes taking the place of oxygen in the type HH.O (as in mercaptan); someti taking the place of carbon within a radicle (as in sulphurous anhydride) SO.O, c pared with carbonic anhydride CO.O; sometimes replacing oxygen within a radicle in sulphide of carbon), CS.S, compared with carbonic anhydride. In the first second cases, the atomic volume of sulphur-compounds may be calculated by at buting to sulphur, (S = 32), the atomic volume 22·6, those of the other elementa maining as above; in the third case, the atomic volume of sulphur appears to greater; viz. 28·6.

Ex.—*Mercaptan*, $C^2H^6S = \left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}S$.

Atomic volume of C^2 . . = 22
„ „ H^6 . . = 33
„ „ S . . = 22·6
„ „ mercaptan . = 77·6

Sulphide of carbon, CS^2 = CS.S.

Atomic volume of C . . = 1
„ „ S (within the radicle) . = 2
„ „ S (without the radicle) . = 2
„ sulphide of carbon . = 6

TABLE B.—*Atomic Volumes of Liquid Sulphur-compounds.*

Substance.	Formula.	Atomic Weight.	Atomic Volume at the Boiling Point	
			Calculated.	Observed.
Mercaptan . . .	C^2H^6S	62	77·6	76·0... 76·1 at 36°
Amylic mercaptan . .	$C^5H^{12}S$	104	143·6	140·1...140·5 „ 120
Sulphide of methyl .	C^2H^6S	62	77·6	75·7 . . „ 41
Sulphide of ethyl . .	$C^4H^{10}S$	90	121·6	120·5...121·5 „ 91
Disulphide of methyl .	$C^2H^6S^2$	94	100·2	100·6...100·7 „ 114
Sulphurous anhydride .	SO^2	64	42·6	43·9 . . „ −8
Sulphite of ethyl . .	$C^4H^{10}SO^3$	138	149·4	148·8...149·5 „ 160
Sulphide of carbon .	CS^2	76	62·2	62·2... 62·4 „ 47

Chlorides, Bromides, and Iodides.—In liquid compounds of this class, the ato volume of Cl is supposed to be 22·8, that of Br = 27·8, and that of I = 37·5, thos the other elements remaining as above.

TABLE C.—*Atomic Volumes of Liquid Chlorides, Bromides, and Iodides.*

Substance.	Formula.	Atomic Weight.	Atomic Volume at the Boiling Point.	
			Calculated.	Observed.
lorinated ethylene .	$C^2H^2Cl^2$	97	78·6	75·9 . at 37° C.
ride of carbon . .	C^2Cl^4	166	113·2	115·4 . . „ 123
ride of ethylene . .	$C^2H^4Cl^2$	99	89·6	85·8... 86·4 „ 85
monochlorinated .	$C^2H^3Cl^3$	133·5	106·9	105·4...107·2 „ 115
dichlorinated .	$C^2H^2Cl^4$	168	124·2	120·7...121·4 „ 137
trichlorinated .	C^2HCl^5	202·5	141·5	143 . . „ 154
ride of tetrylene .	$C^4H^8Cl^2$	127	138·6	129·5...133·7 „ 123
ochlorinated chloride methyl . . .	CH^2Cl^2	85	67·6	64·5 . . „ 30·5
roform . . .	$CHCl^3$	119·5	84·9	84·8... 85·7 „ 62
ride of carbon . .	CCl^4	154	102·2	104·3...107·0 „ 78
ride of ethyl . .	C^2H^5Cl	64·5	72·3	71·2... 74·5 „ 11
monochlorinated .	$C^2H^4Cl^2$	99	89·6	86·9... 89·9 „ 64
dichlorinated .	$C^2H^3Cl^3$	133·5	106·9	105·6...109·7 „ 75
ride of amyl . .	$C^5H^{11}Cl$	106·5	138·3	135·4...137·0 „ 102
ral	C^2HCl^3O	147·5	108·1	108·4...108·9 „ 96
ride of acetyl . .	C^2H^3OCl	78·5	73·5	74·4... 75·2 „ 55
ride of benzoyl . .	C^7H^5OCl	140·5	139·5	134·2...137·8 „ 198
nine	Br^2	160	55·6	54 ... 28·7 „ 63
nide of methyl . .	CH^3Br	95	55·3	58·2 . . „ 13
nide of ethyl . .	C^2H^5Br	109	77·3	78·4 . . „ 41
nide of amyl . .	$C^5H^{11}Br$	151	143·3	149·2 . . „ 119
nide of ethylene . .	$C^2H^4Br^2$	188	99·6	97·5... 99·9 „ 130
de of methyl . .	CH^3I	142·1	65·0	65·4... 68·3 „ 43
de of ethyl . .	C^2H^5I	156·1	87·0	85·9... 86·4 „ 71
de of amyl . .	$C^5H^{11}I$	198·1	153·0	152·5...155·8 „ 147
ride of sulphur . .	SCl	67·5	. .	45·7 . . „ 140
ride of phosphorus .	PCl^3	137·5	. .	93·9 . . „ 78
nide of phosphorus .	PBr^3	271	. .	108·6 . . „ 175
ride of silicon . .	$SiCl^4$	170	. .	121·6 . . „ 59
nide of silicon . .	$SiBr^4$	348	. .	144·0 . . „ 153
ride of arsenic . .	$AsCl^3$	181·5	. .	94·8 . . „ 133
ride of antimony .	$SbCl^3$	235·5	. .	100·7 . . „ 223
nide of antimony .	$SbBr^3$	369	. .	116·8 . . „ 275
ride of tin . .	$SnCl^4$	260	. .	132·4 . . „ 115
ride of titanium . .	$TiCl^4$	92	. .	126·0 . . „ 136

e compounds PCl^3 and $AsCl^3$, have nearly equal atomic volumes: whence it may
ferred that phosphorus, and arsenic, in their liquid compounds, have equal atomic
nes. The same conclusion may be drawn regarding tin and titanium since the
ic volumes of $SnCl^4$ and $TiCl^4$ are nearly equal.

trogen-compounds.—In compounds belonging to the ammonia type, the atomic
ne of nitrogen is 2·3. This result is deduced from the observed atomic volume of
ylamine C^6H^7N, which is 106·8. Now the atomic volume of $6C + 7H = 6 . 11 +$
5 = 104·5, which number, deducted from 106·8, leaves 2·3 for the atomic volume
rogen.

e atomic volume of cyanogen deduced from the observed atomic volume of cyanide
enyl, $CN.C^6H^5$, or C^7H^5N, is nearly 28. Thus:—

Atomic volume of C^7H^5N = 121·6
„ „ C^6H^5 = 93·5
„ „ CN = 28·1

nilar calculation, founded on the observed atomic volume of cyanide of methyl,
N, gives, for the atomic volume of cyanogen, the number 26·8. The atomic volume
quid cyanogen determined directly at 37° or 39° C. above its boiling point, is

between 28·9 and 30·0. As a mean of these values, the atomic volume of cyano may be assumed to be 28; and with this value the atomic volumes of the liquid nides are calculated. Thus, for

$$\text{Oil of mustard (sulphocyanate of allyl), } C^4H^5NS = \left.\begin{matrix}CN\\C^3H^5\end{matrix}\right\}S.$$

Atomic volume of C^3H^5 . . . . = 60·5
„ „ CN . . . . = 28·0
„ „ S (without the radicle) = 22·6
„ „ oil of mustard . . = 111·1

The atomic volumes of compounds containing the radicle NO^2, are calculated on hypothesis that the atomic volume of that radicle is 33, which agrees nearly with observed atomic volume of liquid peroxide of nitrogen. Thus: the atomic volum nitrite of amyl, $C^5H^{11}NO^2$ = at. vol. of C^5H^{11} + at. vol. of $NO^2 = 115{\cdot}5 + 33 = 148{\cdot}5$.

TABLE D.—*Atomic Volumes of Liquids containing Nitrogen.*

Substance.	Formula.	Atomic Weight.	Atomic Volume at the Boiling Point.	
			Calculated.	Observed.
Ammonia . . .	H^3N	17	18·8	22·4... 23·3 at 10°...16°
Ethylamine . .	C^2H^7N	45	62·8	65·3 . . at 18
Tetrylamine . .	$C^4H^{11}N$	73	106·8	
Amylamine . . .	$C^5H^{13}N$	87	128·8	125·0 . . „ 94
Octylamine . . .	$C^8H^{19}N$	129	194·8	190·0 . . „ 170
Phenylamine . .	C^6H^7N	93	106·8	106·4...106·8 . „ 184
Toluidine . . .	C^7H^9N	107	128·8	
Ethylphenylamine .	$C^8H^{11}N$	121	150·8	150·6 . . „ 204
Diethylphenylamine .	$C^{10}H^{15}N$	149	194·8	190·5 . . „ 213
Cyanogen . . .	CN	26	28·0	28·9... 30·0 . „ 16
Hydrocyanic acid .	CHN	27	33·5	39·1 . . „ 27
Cyanide of methyl .	C^2H^3N	41	55·5	54·3 . . „ 74
Cyanide of ethyl . .	C^3H^5N	55	77·5	77·2 . . „ 88
Cyanide of tetryl .	C^5H^9N	83	121·5	
Cyanide of phenyl .	C^7H^5N	103	121·5	121·6...121·9 . „ 191
Sulphocyanate of methyl	C^2H^3NS	73	78·1	75·2... 78·2 . „ 133
Sulphocyanate of ethyl	C^3H^5NS	87	100·1	99·1 . . „ 146
Oil of mustard . .	C^4H^5NS	99	111·1	113·1...114·2 . „ 148
Cyanate of ethyl . .	C^3H^5NO	71	85·3	84·3... 84·8 . „ 60
Peroxide of nitrogen .	NO^2	30	33·0	31·7... 32·4 . „ 40
Nitrate of methyl .	CH^3NO^3	77	68·3	69·4 . . „ 66
Nitrate of ethyl . .	$C^2H^5NO^3$	101	90·3	90·0... 90·1 . „ 86
Nitrobenzene . .	$C^6H^5NO^2$	123	126·5	122·6...124·9 . „ 218
Nitrite of methyl . .	$CH\ NO^2$	161	60·5	61·6 . . „ 14
Nitrite of ethyl . .	$C^2H^5NO^2$	75	82·5	79·2... 84·6 . „ 18
Nitrite of amyl . .	$C^5H^{11}NO^2$	117	148·5	148·4 . . „ 95

From the preceding observations and calculations, it appears that the atomic vol of a compound depends, not merely on its empirical, but likewise on its rational form in other words, not merely on the number of atoms of its elements, but further on manner in which those atoms are arranged. Now a compound may have more one rational formula, according to the manner in which it decomposes; and hen might appear that the calculation of atomic volumes must be attended with consi able uncertainty, inasmuch as the atomic volumes of certain elements, as oxygen sulphur, vary according to the manner in which they enter into the compound. A hyde, for example, may be represented either as $\left.\begin{matrix}C^2H^3\\H\end{matrix}\right\}O$, or as $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}$; and, the atomic volume of oxygen is 12·2 or 7·8, according as it is within or without radicle, the atomic volume of aldehyde will be 56·2 if deduced from the type HH, if deduced from the type HH.O. But the atomic weight of aldehyde, and its fic gravity at a given temperature are invariable; it cannot therefore have two rent atomic volumes. It must be remembered, however, that, in speaking of a ound as having several rational formulæ, we consider it rather in a dynamical in a statical point of view; as under the influence of disturbing forces, and on point of undergoing chemical change. But if, on the other hand, we regard a ound in its fixed statical condition, as a body possessing definite physical proper- a certain specific gravity, a certain boiling point, rate of expansion, refractive r, &c., we can scarcely avoid attributing to it a fixed molecular arrangement, or, events, supposing that the disposition of its atoms is confined within those limits constitute chemical types. It is found, indeed, that isomeric liquids exhibit atomic volumes only when they belong to the same chemical type. If this view rrect, the relation between the atomic volumes of elements and compounds, may render valuable service in determining the rational formula which belongs to a ound in the state of rest. Thus of the two atomic volumes just calculated for yde, the number 56·2, deduced from the formula $C^2H^3O.H$, agrées with the ved atomic volume of aldehyde, which is between 56·0 and 56·9, better than 51·8, number deduced from $\left.\begin{matrix}C^2H^3\\H\end{matrix}\right\}O$. This result leads to the conclusion that the ydes belong to the hydrogen type rather than to the water type.

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* Between 44° and 50° above the boiling point.
† Between 37° and 39° above the boiling poi
‡ About 55° above the boiling point.
§ 27° above the boiling point.

here are many groups of liquid compounds, irrespective of isomerism or similarity pe, the members of which have equal or nearly equal atomic volumes. The following table exhibits the calculated atomic volumes of several of these groups:

ter	H^2O	18·8
nonia	NH^3	18·8
nine	Br^2	55·6
ogen	$(CN)^2$	56·0
hyde	C^2H^4O	56·2
nide of methyl	C^2H^3N	55·5
nide of methyl	CH^3Br	55·3
hol	C^2H^6O	62·8
ic acid	$C^2H^4O^2$	64·0
nate of methyl	$C^2H^4O^2$	64·0
nate of methyl	C^2H^5NO	63·3
ylamine	C^2H^7N	62·8
hide of carbon	CS^2	62·3
de of methyl	CH^3I	65·0
one	C^3H^6O	78·2
nide of ethyl	C^3H^5N	77·5
hocyanate of me- yl	C^2H^3NS	78·1
hide of methyl	C^2H^6S	77·6

Ether	$C^4H^{10}O$	106·8
Tetrylic alcohol	$C^4H^{10}O$	106·8
Phenylic alcohol	C^6H^6O	106·8
Tetrylamine	$C^4H^{11}N$	106·8
Phenylamine	C^6H^7N	106·8
Butyric acid	$C^4H^8O^2$	108·0
Acetate of ethyl	$C^4H^8O^2$	108·0
Acetic anhydride	$C^4H^6O^3$	109·2
Chloral	C^2HCl^3O	108·1
Dichlorinated chloride of ethyl	$C^2H^3Cl^3$	106·9
Monochlorinated chloride of ethylene	$C^2H^3Cl^3$	106·9
Bromide of phosphorus	PBr^3	108·6
Valeraldehyde	$C^5H^{10}O$	122·2
Cyanide of tetryl	C^5H^9N	121·5
Bitter almond oil	C^7H^6O	122·2
Cyanide of phenyl	C^7H^5N	121·5
Sulphide of ethyl	$C^4H^{10}S$	121·6

ese groups exhibit an approach to the uniformity of atomic volume which is ved in the gaseous state.

rthelot has adduced a number of examples, showing that when a liquid compound med by the union of two other liquids, whose specific volumes are denoted by A and th elimination of x atoms of water, the specific volume of the compound is nearly $+ B - xC$ (the atomic volume of water being denoted by C). Berthelot's obserns, however, were made at medium temperatures, not at the boiling points of the ls (Ann. Ch. Phys. [3] xlviii. 322).

Of Solid Compounds. (H. Kopp, Pogg. Ann. xlvii. 133; lii. 243, 262; Ann. Pharm. xxxvi. 1.—Ammermüller, Pogg. Ann. xlix. 341.—H. Schröder, *ibid.* 2; lii. 269, 282; cvi. 226; cvii. 113.—Filhol, Ann. Ch. Phys. xxi. 415.—fair and Joule, Chem. Soc. Mem. ii. 477; iii. 54, 199; Chem. Soc. Qu. J. 1.—H. Schiff, Ann. Ch. Pharm. cvii. 64; cxii. 88.—Gm. i. 67—86.)

e most general relation that has been observed between the atomic volumes of id compounds is, that *isomorphous compounds have equal atomic volumes*, in other , their densities are proportional to their atomic weights. Such is the case, for ple, with carbonate of strontium (strontianite) and carbonate of lead (cerussite).

Formula.	At. Weight.	Sp. Gr.	At. Volume.
Sr^2CO^3	147·6	3·60	41·0
Pb^2CO^3	267·4	6·47	41·4

If the crystalline forms are only approximately similar, the atomic volumes also a only approximately equal, the difference being less as the angles of the two crystalli forms are more nearly equal, and their axes more nearly in the same ratio. A alteration of atomic volume, such as is often produced by the introduction of o element into a compound in place of another, is attended with a corresponding alter tion of crystalline form. The atomic volume may likewise be altered without a change in the composition of the body, viz. by change of temperature, and this al produces in most cases, as Mitscherlich has shown, a corresponding alteration in t magnitude of the angles. In crystals of the regular system, however, variation temperature produces no alteration either in form or in atomic volume.

In **dimorphous** compounds, each modification has a density, and therefore also atomic volume, peculiar to itself.

The equality, exact or approximate, of the atomic volumes of isomorphous compoun has been traced by Hugo Schiff, through several classes of salts, especially in the sulpha of the general form, $M^2SO^4.7H^2O$ (*vitriols*), in the double sulphates of the magnesi class, $\left.\begin{matrix}K ; NH^4\\ M\end{matrix}\right\}SO^4.3H^2O$, and in the alums. The atomic volumes of these co pounds are given in the following table:

Formula.	Atomic Weight.	Specific Gravity.	Atomic Volum
Vitriols.			
$Mg^2SO^4 . 7H^2O$	246	1·685	146
$Zn^2SO^4 . 7H^2O$	287	1·853	146·9
$Ni^2SO^4 . 7H^2O$	281·2	1·931	145·6
$Co^2SO^4 . 7H^2O$	281	1·924	146
$Fe^2SO^4 . 7H^2O$	278	1·884	147·5
$(MgCu)SO^4 . 7H^2O$	265·7	1·813	146·5
$MgZnSO^4 . 7H^2O$	266·5	1·817	146·6
$MgCdSO^4 . 7H^2O$	290·0	1·983	146·2
Double Magnesian Sulphates.			
$(NH^4)MgSO^4 . 3H^2O$	180	1·680	107·1
$KMgSO^4 . 3H^2O$	201·2	1·995	100·9
$(NH^4)ZnSO^4 . 3H^2O$	200·5	1·910	104·9
$KZnSO^4 . 3H^2O$	221·7	2·153	103
$(NH^4)NiSO^4 . 3H^2O$	197·6	1·915	103·2
$KNiSO^4 . 3H^2O$	218·8	2·123	103·1
$(NH^4)CoSO^4 . 3H^2O$	197·5	1·873	105·4
$KCoSO^4 . 3H^2O$	218·7	2·154	101·6
$(NH^4)FeSO^4 . 3H^2O$	196	1·813	108·1
$KFeSO^4 . 3H^2O$	217·2	2·189	99·2
$(NH^4)CdSO^4 . 3H^2O$	223·7	2·073	107·9
$KCdSO^4 . 3H^2O$	244·9	2·438	100·5
$(NH)^4CuSO^4 . 3H^2O$	199·7	1·931	103·4
$KCuSO^4 . 3H^2O$	220·9	2·137	103·3
Alums.			
$KAl^2S^2O^8 . 12H^2O$	474·6	1·722	275·6
$NaAl^2S^2O^8 . 12H^2O$	458·4	1·641	279·2
$(NH^4)Al^2S^2O^8 . 12H^2O$	453·4	1·621	279·6
$KCr^2S^2O^8 . 12H^2O$	500·8	1·845	271·4
$(NH^4)Cr^2S^2O^8 . 12H^2O$	479·6	1·736	276·2
$(NH^4)Fe^2S^2O^8 . 12H^2O$	482·0	1·712	281·4

The atomic volumes of the vitriols are very nearly equal; so likewise are those the alums. Those of the double magnesian sulphates, $M(K ; NH^4)SO^4 3H^2O$, dif somewhat more, the difference between the greatest and least amounting to 8·9. is remarkable, however, that the atomic volume of the ammonium- and potassiu salts in each pair differs from the mean value (104) by nearly equal values, the form in excess, the latter in defect; thus, in the first pair we find, 107·1 − 104 = + 3· and 100·9 − 104 = − 3·1; and in the second pair: 104·9 − 104 = + 0·9; a 103 − 104 = − 1·0.

he following table contains the atomic volumes of certain chlorides, bromides, iodides:—

Formula.	Atomic Weight.	Specific Gravity.	Atomic Volume.
Chlorides.			
loride of hydrogen	36·5	1·501	24·3
loride of lead	139·5	5·78	24·2
loride of iron (ferrosum)	63·5	2·528	25·1
loride of calcium	55·5	2·205	25·2
loride of nickel	65·0	2·56	25·3
loride of mercuricum	135·5	5·320	25·5
loride of silver	143·5	5·517	26·0
loride of cuprosum	98·9	3·70	26·7
loride of strontium	79·5	2·96	26·9
loride of sodium	58·5	2·148	27·2
loride of barium	104·1	3·82	27·2
Bromides.			
omide of hydrogen	82·0	2·00	41·0
omide of mercurosum	281·0	7·307	38 4
omide of sodium	104·0	2·952	35·2
omide of barium	149·6	4·23	35 3
omide of mercuricum	181·0	5·92	30·6
omide of silver	189·0	6·353	29·8
omide of lead	185·0	6·63	28·0
Iodides.			
dide of hydrogen	128·0	2·25	57·0
dide of potassium	166·2	2·85	58·3
dide of sodium	150·0	3·45	43·5
dide of mercurosum	327·0	7·644	42·8
dide of silver	235·0	5·35	43·9
dide of barium	195·6	4·917	39·8
dide of mercuricum	227·0	5·91	38·4
dide of lead	231·0	6·07	38·1

t will be observed that the atomic volumes of the bromides and iodides do not
ee among themselves so nearly as those of the chlorides. The atomic volume of a
mide is not, for the most part, the mean between those of the corresponding chloride
iodide, but approaches more nearly to that of the chloride. (Schiff.)

hat isomorphous compounds do in many instances occupy equal atomic volumes
ufficiently apparent from the preceding examples. Nevertheless, Schröder con-
les, from calculations founded partly on his own determinations of specific gravity,
tly on those of other observers, that equality of atomic volume is not necessarily
nected with similarity of crystalline form, but is exhibited by heteromorphous
nents and compounds quite as often as by those which are isomorphous, if not
ner. (Pogg. Ann. cvi. 226; cvii. 113.)

he connection between the atomic volumes of compounds and of their elements has
been so fully examined in solids as in liquids; nevertheless certain general rela-
s have been shown to exist. The most important of these relations, first pointed
by Schröder, and further established by Kopp, is that *equivalent quantities of dif-*
nt elements, in uniting with the same quantity of a given element (*or compound*
icle) *receive equal increments of volume.* Thus, when 207·4 grammes, or 18·44
cent. of lead (Pb^2), 112 grm. = 13 c.c. cadmium (Cd^2), 63·7 grm. = 7·2 c.c. copper
^{2}), or 65·2 grm. = 9·2 c.c. zinc (Zn^2), unite with 16 grms. of oxygen (O) to form
compounds Pb^2O, Cd^2O, &c., the increment of volume is found to be in each case
rly 2·6 cubic centimetres. Again, in the oxidation of 112 grm. iron (Fe^4) to ferric
le, Fe^4O^3, the increment of volume is 8·1 = 3 × 2·7 c.c. The explanation of this
appears to be that certain elements enter into combination with the same atomic
ume that they occupy in the separate state. Such, according to Kopp, is the case
the heavy metals: so that, by determining experimentally the atomic volumes of
r oxides, chlorides, nitrates, &c., and deducting therefrom the volumes of the
als themselves as given in the table (p. 442), the atomic volumes of O, Cl, NO^3, &c.,

which cannot be observed directly, may be found; thus, a comparison of the oxide above-mentioned shows that the atomic volume of oxygen in these compounds is 2·6.

The metals of the alkalis and earths do not appear to enter into combination wit the same volume that they occupy in the free state. Their atomic volumes in com bination must, therefore, be calculated by deducting from the observed atomic volume of their salts, the chlorides for example, the volume of the chlorine as determine from the chlorides of the heavy metals, this determination of course resting on th assumption that the atomic volume of the chlorine in combination is the same in a analogous compounds.

On these principles, Kopp has made the following estimations of the atomic volume of the alkali-metals, earth-metals, and certain salt-radicles:—

NH^4 in its salts	17·4
K " "	18·7
Na " "	10·4
Ba " "	11·4
Sr " "	8·6
Ca " "	4·8
CO^3 in the carbonates of Pb, Cd, Fe, Mn, Ag, Zn, Ba, Ca, K, Mg, Na, Sr	12·1
NO^3 in the nitrates of Pb, Ag, NH^4, Ba, K, Na, Sr	28·6
SO^4 in the sulphates of Cu, Ag, Zn, Ca, Mg, Na	18·9
SO^4 in the sulphates of Pb, Ba, K, Sr	14·9
Cl in the chlorides of Pb, Ag, Ba, Na	15·7
Cl in the chlorides of NH^4, Ca, K, Ccu, Hg, Hhg, Sr	19·6
O in the oxides Pb^2O, Cd^2O, Cu^2O, Hg^2O, Zn^2O, SnO, Sb^2O^3, Fe^4O^3, Co^4O^3, Bi^2O^3, Pb^3O^2	2·6
O in the oxides Ccu^2O, Ag^2O, Hhg^2O, Mo^2O^3	5·2

These values were determined in 1841, and many of them require correction accor ing to the atomic weights and densities since established. According to Schröde (*loc. cit.*), the relations upon which they depend are true only with regard to isomo phous compounds, being regulated by the following general law: "If two elements groups of elements, *A*, *B*, &c., unite with other elements or groups, *C*, *D*, *E*, &c., forr ing compounds *AC* and *BC*, *AD* and *BD*, *AE* and *BE*, &c., which belong to the san type, and are isomorphous by pairs, the differences of atomic volume of *AC* and *BC*, *A* and *BD*, *AE* and *BE*, &c., are always equal; but, if these pairs of compound are n isomorphous, or belong to different types, then the differences of atomic volume a unequal."

Messrs. Playfair and Joule have observed some remarkable relations betwe the atomic volumes of crystallised salts and that of the water which they contain, vi 1. In certain highly hydrated salts, viz. the *arsenates and phosphates with* 12 *at. wat* and in *carbonate of sodium with* 10 *at. water*, the volume of the entire molecule is t same as that of the water of crystallisation frozen into ice, the particles of the ac and base appearing to be interposed between those of the water without increasi the total bulk. The following table contains the specific gravity of some of the salts, as calculated upon this hypothesis, and as determined by direct experiment:

Salt.	Specific Gravity.	
	Exp.	Calc.
$Na^2CO^3 . 10H^2O$	1·454	1·463
$Na^2HPO^4 . 12H^2O$	1·525	1·527
$Na^3PO^4 . 12H^2O$	1·622	1·622
$Na^2HAsO^4 . 12H^2O$	1·736	1·736
$Na^3AsO^4 . 12H^2O$	1·804	1·534

In *cane-sugar* and *milk-sugar*, the atomic volume is the same as that of the hydroge and oxygen, supposed to be united as water and frozen. Specific gravity of cane sugar on this hypothesis = 1·586; by experiment = 1·586; of milk-sugar, by calculatio 1·534; by experiment 1·531.

2. In another class of salts, including the *hydrated magnesian sulphates* ($M^2O.SO$ + $6H^2O$), *normal sulphate of aluminium*, *borax*, *pyrophosphate of sodium*, and th *alums*, the atomic volume is made up of the solid water and of the base (M^2O c M^4O^3); in other words, the volume of the hydrated salt is made up of that of the wate of crytallisation frozen into ice, and that of the base as it exists in the free state, c in the anhydrous salt. (For details see the memoirs cited on page 449.)

ATOMIC WEIGHTS. The ultimate constitution of matter, and its finite c infinite divisibility, have been made the subjects of speculation and argument fror almost the earliest times. The molecular idea of matter seems to have prevailed i the primitive philosophies of the Hindoos, Phœnicians, and Egyptians, from the las whom it was probably transmitted to the Greeks. Among them, we find the notion finite divisibility constituting the basis of the cosmogony of Democritus, who appa- ntly acquired the doctrine directly from Leucippus. Subsequently Epicurus, and the picureans generally, extended the atomic hypothesis; which, however, was strongly posed by Empedocles and the later Pythagoreans, who contended for the in- ite divisibility of matter, and for its continuity in any given mass. Plato and ristotle also, especially the latter, advocated the notion of infinite divisibility. In odern times, the doctrine of material atoms was maintained by Newton, and opposed Descartes, Leibnitz, and Euler. After the time of Euler, the question of the ultimate nstitution of matter fell into some neglect, although the non-atomic view seems to ve been generally preferred, until Dalton, in 1804—8, revived the atomic hypothesis, order to account for the phenomena of chemical combination in definite and multiple oportions, which he first brought prominently into notice. Prior to his discovery, the emical composition of bodies, as determined by analysis, had been expressed in ntesimal proportions only, whereby the relations in composition of different bodies ere in great measure concealed from observation. Thus, the relative composition of efiant gas and marsh gas, was expressed very imperfectly by saying that the former ntained 85·7 per cent. of carbon and 14·3 per cent. of hydrogen, while the latter ntained 75·0 per cent. of carbon and 25·0 per cent. of hydrogen. It was from the sults of an examination of these two gases that Dalton was first led to the conception his theory. He ascertained that both gases consist of carbon and hydrogen only, d set out the centesimal composition of each in the customary manner. But he served further, that the ratio of hydrogen to carbon is exactly twice as great in the e case as in the other; that in olefiant-gas, for instance, the carbon is to the hydro- n as 6 to 1, whereas in marsh-gas it is as 6 to 2. Or, in other words, a given antity of carbon unites with either one or two proportions of hydrogen to form the spective compounds, olefiant-gas and marsh-gas. Dalton, whose turn of mind was sentially mechanical, explained the constitution of these two compounds by supposing at the first consisted of 1 at. of carbon united with 1 at. of hydrogen ●⊙, while e second consisted of 1 at. of carbon united with 2 at. of hydrogen ⊙●⊙, the atom carbon being considered to have 6 times the weight of the atom of hydrogen. e then calculated the composition of other bodies on the same plan, and found, for stance, that the quantity of hydrogen which unites with 6 pts. of carbon to form efiant gas, unites with 8 pts. of oxygen to form water. Hence water was represented the symbol ⊙○, the atom of oxygen being considered to have 8 times the weight the atom of hydrogen. The crowning point of Dalton's theory was reached when discovered that the numbers which expressed the respective combining proportions carbon and oxygen with 1 pt. of hydrogen, also expressed the proportions in which ey combine with one another. Thus the ratio of carbon to oxygen in carbonic oxide s was found to be as 6 to 8; whereas in carbonic anhydride gas it was as 6 to *ice* 8. The former compound he considered to result from the union of 1 at. of rbon with 1 at. of oxygen ●○; and the latter to result from the union of 1 at. of rbon with 2 at. of oxygen ○●○. Dalton extended the same views to the com- unds of nitrogen, and concluded that the quantity of that element which united with pt. of hydrogen to form ammonia ⦶⊙, united with 8 pts. of oxygen to form nitrous s ⦶○. We may apply this formula for nitrous gas to the compound known as trous anhydride, though, from an error in the rough process of analysis then adopted, was intended to apply to what is now called nitric oxide, or deutoxide of nitrogen. ven at the present day, it is highly interesting to compare the information afforded Dalton's expressions for the above-mentioned compounds, with the information forded by a statement of their respective centesimal proportions, thus:—

	Dalton's Expressions.		Centesimal Proportions.
Olefiant-gas . . .	6 + 1	●⊙	85·72 + 14·28
Marsh-gas . . .	6 + *twice* 1	⊙●⊙	75·00 + 25·00
Water	8 + 1	○⊙	88·89 + 11·11
Carbonic oxide . .	6 + 8	●○	42·86 + 57·14
Carbonic anhydride .	6 + *twice* 8	○●○	27·27 + 72·73
Ammonia . . .	5 + 1	⦶●	82·35 + 17·65
Nitrous gas . . .	5 + 8	⦶○	36·80 + 63·20

alton thus established that general principle in chemistry known as the law of mbination in definite and multiple proportions. He showed that a par- cular number might be selected for every element, in such a manner that the propor- ons by weight in which any two or more elements combine with one another, should always in the ratios of their respective numbers, or of different multiples of those mbers. And he accounted for this law by supposing that the elements unite with one another atom to atom, and that the proportional number accorded to each particul element expresses the relative weight of its atom. Hydrogen being the lighte substance in nature, was at once chosen by Dalton as the unit in his scale of atom weights, and the weights of the atoms of other elements were established by asce taining, directly or indirectly. the respective quantities of those elements which uni either with 1 pt. of hydrogen, or with the quantity of some other element which unit with 1 pt. of hydrogen. But many chemists, who speedily acknowledged the truth Dalton's laws of combination, refused to admit the atomic doctrine which he had d duced therefrom. Among these was Davy, who introduced the word proportion a substitute for Dalton's word atom, conceiving the use of the latter word to be objectio able, as involving a theoretical assumption. At the present day, the word ato is most generally employed by chemists; but, while some use it in its strict Da tonian materialistic sense, others use it, in an abstract sense only, to express t smallest indivisible combining proportion of a body, and consider the proportion number of a body as an ultimate or unexplained property pertaining to it. Dalton symbols were speedily replaced by those now in use, which represent the abbreviat names of the elements. Every such symbol is used to express one atomic proportion its particular element. Thus, Cl stands for 35·5 pts. of chlorine, Na for 23 pts. sodium, and As for 75 pts. of arsenic, as compared with 1 pt. by weight of hydrog Every compound body being composed of two or more elementary atoms, is expres by an allocation of symbols. Thus, common salt or chloride of sodium is represent by the formula NaCl, which implies a compound of 23 pts., or 1 combining proporti of sodium, united with 35·5 pts., or 1 combining proportion of chlorine. Again, t chloride of arsenic is represented by the formula $AsCl^3$, which implies a compound 75 pts., or 1 combining proportion of arsenic, united with 106·5 pts. or 3 combini proportions of chlorine.

In the case of compound bodies, the sum of the atomic weights of the constitue elements is taken as the atomic weight of the compound. Thus, the atomic weight chloride of sodium is 58·5 and that of trichloride of arsenic 181·5. The relati quantity of a compound body, represented by its formula, is frequently spoken of its atom, and there is nothing unphilosophical in such an employment of the wo By the atom of sodium, for instance, is understood, the least indivisible proporti of the elementary body sodium, and by the atom of chloride of sodium, the le indivisible proportion of the compound body chloride of sodium, that can ha any existence. Soon after the publication of Dalton's theory, it received a valua corroboration, through its adaptability to groupings of elements or compound ato Wollaston, in the course of some analytical experiments, noticed, that if in the t carbonates of potassium, the weight of oxide of potassium be taken as constant, th the weights of carbonic anhydride in each salt are to one another as 1 to 2; a Thomson made a similar observation with regard to the two oxalates of potassiu Hence these salts were represented at that time, in accordance with Dalton's views, consisting respectively of one compound atom of oxide of potassium, united with o or two compound atoms of carbonic anhydride, and with one or two compound atoms oxalic anhydride. The compound atom of a body, or more correctly the atom of a co pound body, is now often spoken of as its molecule; but, in many cases, there is a d tinction between the application of the two words which will be presently adverted

The accuracy of Dalton's laws of combination in definite and multiple proportio was confirmed by a reference to the previous neglected researches of Wenzel a Richter upon the double decomposition of salts; and by the subsequent brillia researches of Gay-Lussac upon the laws of combination by volume; in which showed that the combining proportions of simple and compound gases might be e pressed volumetrically or by bulk, as well as numerically or by weight.

It is worth while to refer for a few moments to the above-mentioned experime of Wenzel and Richter. If we add together solutions of chloride of sodium a nitrate of silver, which are both neutral salts, we get by double decompositi chloride of silver and nitrate of sodium, and the mixture still remains neutral. Th is no redundancy or deficiency of either sodium or silver, but the quantity of sodiu separated from its chloride is exactly sufficient to replace the silver separated from nitrate, and *vice versâ*. Wenzel, of Freyberg in Saxony, as early as the year 17 made very many analyses of salts with great accuracy, and was thereby enabled account for this neutrality, resulting from the mutual decomposition of neutral sal by showing that in all salts the quantities of salt-residue, so to speak, which are co bined with equal weights of some one metal, will also combine with equal weights any other metal. Thus, if y grains of chloride of sodium, and z grains of nitrate sodium alike contain x grains of sodium, then $(y - x) + w$ grains of chloride of silv and $(z - x) + w$ grains of nitrate of silver will alike contain w grains of silve because the quantities x and w represent the relative combining proportions of t metals, silver and sodium, which can take the place of one another, and unite with t e amount of chlorine or other salt radicle, or residue. Richter, of Breslau in sia, published, in the year 1792, what may be regarded as an extension of views and experiments of Wenzel. He showed that the neutrality of a saline tion does not change during the direct precipitation or substitution of its metal some other; and that the respective quantities of different metals which displace one ther in salts, all unite with the same weight of oxygen. He also constructed ble of the quantities of different oxides or bases, which contain replaceable unts of metal, and of the quantities of different acids which can be neutralised by se quantities of the respective bases. His experimental results were very inaccu- , but his notions of chemical decomposition, had they received due attention at time, must have led directly to the doctrine of combining proportions, if not to Daltonian theory of atoms. It was not until some time after the publication of ton's views, that Berzelius first called attention to the prior researches of Wensel Richter, as affording a valuable confirmation of the laws of chemical combination ch Dalton had enunciated.

n the establishment of proportional numbers or atomic weights, two distinct nts have to be considered, namely the exact determination of the ratios, according which bodies combine, and the correct expression or interpretation of those ratios. first is a question of experiment, while the second is one of judgment or inference. us whether the ratio of hydrogen to nitrogen in ammonia is as 1 to 5, or as 1 to 7 is a question of mere experiment: but whether the atom, or smallest indivisible bining proportion of nitrogen is 4·67 times, or 14 times as heavy as the atom or llest indivisible combining proportion of hydrogen, and consequently, whether the lecule of ammonia consists of one light atom of nitrogen united with 1 of hydro- , or of one heavy atom of nitrogen united with 3 of hydrogen, are questions for judgment, which can only be decided by an intimate acquaintance with, and careful sideration of very many circumstances relating to the respective bodies and their geners. The numbers originally chosen by Dalton to express the ratios in which different elements unite with 1 part of hydrogen, are most of them very in- rect. Thus his number for nitrogen was 5 instead of 4·67, that for carbon 5 instead , that for oxygen 7 instead of 8, that for phosphorus 9 instead of 10·33, that for phur 13 instead of 16, and similarly with the remainder. Davy raised the number oxygen from 7 to 7·5, which Prout, soon after, on theoretical grounds increased to 8. t the first series of numbers, deduced from trustworthy experiments, was drawn up Berzelius, whose results, the work of a lifetime, must ever excite our highest miration for the marvellous industry and skill by which they were achieved. Of e years, when analytical and synthetical processes have been so greatly simplified improved, many of his atomic weights have undergone slight corrections at the ds of Dumas, Marignac, Pelouze, Stas, Maumené, Erdmann, Marchand, and others, the general exactitude of his numbers still remains unimpeached. Berzelius, owing the example of Wollaston in this country, selected the atomic weight of gen as the unit of his scale, and the same plan was adopted until within this last enty years by continental chemists in general. The atomic weight of oxygen s fixed at 100, and those of the other elements estimated in accordance therewith; the simpler numbers by which most of the ratios are expressed on the hydrogen le, have eventually secured for it the preference.

In the year 1815, Prout, in a paper "on the relations between the specific gravities bodies in the gaseous state, and the weights of their atoms," propounded the idea t the atomic weights of all bodies are multiples of the atomic weight of hydrogen. s opinion was shared by Dalton on other grounds, and met with very general ac- tance in this country. But it was never acknowledged by Berzelius, or until lately any large number of continental chemists. Although Prout's views must be con- ered, in the present state of our knowledge, to rest rather upon a speculative than a stantial philosophical basis, it cannot be denied that the tendency of modern investi- ion has been to confirm his law; or rather a certain modification of it, which Dumas t introduced in a definite form, but which Prout himself seems to have admitted. Ac- ding to this modification, the atomic weights of all bodies are multiples by whole mbers of a submultiple of the atomic weight of hydrogen. A striking confirmation of s view occurred in the year 1840, when Dumas and Stas showed that the atomic ight of carbon is exactly 6. In 1843 Dumas also showed that oxygen and hydrogen ite to form water exactly in the ratio of 8 to 1, and his experiments were confirmed by se of Erdmann and Marchand. Then Pelouze and Marignac separately ascertained t the atomic weight of nitrogen is 14; and Maumené, Marignac, and Pelouze, sepa- ely ascertained that the atomic weights of chlorine, silver, and potassium coincide nost absolutely with the numbers of 35·5, 108, and 39 respectively. Pelouze showed o that the atomic weights of sodium, barium, and arsenic are 23, 68·5, and 75 respec- ely. At the present time, out of fifty-eight elementary atomic weights, calculated from the acknowledged best experiments, not more than half a dozen differ appreciabl from multiples by whole numbers of half the atomic weight of hydrogen. Some o these exceptional numbers ought probably to be doubled, whereby they would accor with Prout's modified law, while others of them can hardly be looked upon as satisfac torily determined. It is worthy of observation also that the smallest atomic weight which, as a general rule, are those of the best known, and most easily estimate elements, accord the most precisely with Prout's law. Dumas is of opinion tha some of the exceptional numbers are multiples of one-fourth the atomic weight o hydrogen. Stas, from an elaborate series of experiments, the exactness of which i seems impossible to exceed, has arrived at the conclusion that Prout's law is not tru or at any rate that it is only approximatively true. He has obtained the followin numbers for potassium, sodium, silver, sulphur, nitrogen, chlorine, and lead. Eac number has been derived from numerous closely concordant experiments performed b different processes, on a scale of magnitude and with a degree of delicacy, hithert unequalled. His number for potassium, however, is the only one which differs con siderably *i.e.* ⅓ per cent. from the usually accepted number:

		Stas's numbers.		Differences.
Potassium	39	39·130	+	0·130
Sodium	23	23·050	+	0·050
Silver	108	107·943	−	0·057
Sulphur	32	32·074	+	0·074
Nitrogen	14	14·041	+	0·041
Chlorine	35·5	35·460	−	0·040
Lead	103·5	103·457	−	0·043

Hence it is apparent that the differences in the experimental determination of th ratios according to which bodies combine with one another, have been reduced withi very narrow limits. But the case is far otherwise when we come to consider the in terpretation of these ratios, or the establishment of the atomic weights of simple an compound bodies. Thus mercury unites with chlorine in two proportions to form calomel and corrosive sublimate respectively. In the former compound the ratio o chlorine to mercury is as 35·5 to 200; and in the latter as 35·5 to 100; or as *twic* 35·5 to 200. We have therefore to decide between the numbers 200 and 100, where with to express the atomic weight of mercury. If we select the number 200, the for mula of calomel will be HgCl, and that of corrosive sublimate $HgCl^2$. If we select th number 100, the formula of calomel will be Hg^2Cl, and that of corrosive sublimate HgCl. Much the same difficulty also exists in those cases in which two elements combin in only one proportion. Thus chlorine unites with silver in the proportion of 35·5 t 108, or to *twice* 54. Now supposing even that we all agree to represent calomel b Hg^2Cl, and corrosive sublimate by HgCl, we have still to consider whether chloride o silver is a body analogous to calomel or to corrosive sublimate, before we can decid upon representing it by the formula Ag^2Cl, in which Ag = 54, or by the formula AgC in which Ag = 108. Again, chlorine unites with aluminium in the single proportio of 35·5 parts of chlorine to 9 parts of aluminium. Chloride of aluminium may conse quently be represented by the formula AlCl, in which Al = 9; or by $AlCl^2$, in whic Al = 18; or by $AlCl^3$, in which Al = 27; or by Al^2Cl, in which Al = 4·5; or b Al^2Cl^3, in which Al = 13·5; or by one of many other possible formulæ. From variety of considerations, more or less complicated, the last formula, Al^2Cl^3, is the on which has been generally but not unanimously adopted. Again, the composition o marsh-gas has been ascertained with the greatest certainty. The ratio of carbon t hydrogen is precisely as 3 to 1. Hence we may represent the gas by the formula CH in which the atomic weight of carbon = 3; or by the formula CH^2, in which C = 6 or by the formula CH^3, in which C = 9; or by the formula CH^4, in which C = 12 or we may represent the gas by the formula C^2H^4, in which C = 6; &c. &c. At th present time, all chemists are agreed that the molecule of marsh-gas contains four atom of hydrogen, but they disagree as to whether it contains two atoms of carbon havin each the value 6, or one atom of carbon only having the value 12.*

It is obvious that the atomic weights of an element and of its combinations, shoul be selected so as to express the entire series of combinations by the simplest series o formulæ; so as best to accord with the chemical properties and metamorphoses of th bodies; so as best to illustrate their analogies with other bodies; and so as to be i relation with their physical properties, such as their specific volumes, specific heats isomorphism, &c. Now it so happens that these different requirements, chemical an physical, are not always satisfied by one and the same number. Hence we have t subordinate requirements, much in the same manner that zoologists and botanists sub- ordinate characters. and to select that atomic weight which fulfils the greatest number, or rather the most important of them. Many of the discrepancies which were formerly ght to exist between the numbers deduced respectively from chemical and physical iderations, have of late years been satisfactorily explained away; and we have y reason to believe that with increasing knowledge leading to higher generalisations, uch anomalies as at present exist will also disappear.

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* Since this article was written (1859) the formula CH^4, in which C = 12, has been almost universall adopted.

a determination of the least indivisible combining proportion, or chemical atom body, it is clear that purely chemical considerations must be entitled to the greatest ght, and to some of these we will now direct our attention. If we examine marsh-, for instance, we soon perceive that its molecule contains four atoms of hydrogen; use we find ourselves able to displace one-fourth, or two-fourths, or three-fourths, ur-fourths of its hydrogen. In other words, we find that its hydrogen is divisible four equal parts; and as the atom of hydrogen expresses the least indivisible part ydrogen that can enter into a combination, it is evident that marsh gas must con- four of such parts, or four atoms, of hydrogen. Thus taking the formula $C^{x}H^4$ for sh-gas, we have the following series of derivatives, the constitution of which could be expressed, save by according four atoms of hydrogen to the molecule of the gas.

$C^{x}H^4$	Marsh-gas	$C^{x}H^4$.	
$C^{x}H^3Cl$	Chloride of methyl	$C^{x}H^3Na$	Sodium-methyl.
$C^{x}H^2Cl^2$	Dichloride of methylene	. .	
$C^{x}HCl^3$	Chloroform	$C^{x}HI^3$	Iodoform.
$C^{x}Cl^4$	Tetrachloride of carbon	. .	

ce the metamorphoses of marsh-gas show that the most simple formula by which ratio of its carbon and hydrogen can be expressed, namely, CH, is not the proper ula of the body. Again, the quantity of marsh-gas, which is the resultant of any tion, cannot be expressed with less than four atoms of hydrogen. Thus, when ic acid is decomposed by heat, we have the reaction, $C^{2xx}H^4O^2 = C^{x}H^4 + C^{x}O^2$. quantity of carbon C^{x}, which unites with 4 pts. of hydrogen to form marsh-gas, es with 32 pts. of oxygen to form carbonic anhydride; but whereas the quantity ydrogen in marsh-gas is experimentally divisible into 4 pts., the quantity of oxy- in carbonic anhydride is experimentally divisible into 2 pts. only; so that while represent marsh-gas by the formula $C^{x}H^4$, we represent carbonic anhydride by formula $C^{x}O^2$, as will be again referred to.

he same class of chemical reasons which induce us to regard marsh-gas as tetra- ic, also induce us to regard ammonia as trihydric. In ammonia we can replace third, or two-thirds, or three-thirds of its hydrogen, but we cannot replace one- th, or two-fourths, or three-fourths. The hydrogen in marsh-gas being divisible 4 equal parts, the hydrogen in ammonia is divisible into 3 equal parts only, and equently the molecule of ammonia contains 3 indivisible proportions or atoms of ogen. We are acquainted with many ammonias in which one, two, and three- ds of the hydrogen are displaced, for example:

$N^{x}H^3$	Ammonia.	$N^{x}HI^2$	Diniodamide
$N^{x}H^2K$	Potassamine	$N^{x}Hg^3$	Trimercuramine, &c. &c.

the most striking illustration of displacement by thirds is afforded by Hofmann's arches on the volatile alkaloids, in which he successively displaced one, two, and e atoms of hydrogen in ammonia by a mere continuation of one and the same ess:

monia.	Ethylia.	Diethylia.	Triethylia.	Ethyl-methyl-aniline.
$N^{x}\begin{cases}H\\H\\H\end{cases}$	$N^{x}\begin{cases}H\\H\\Et\end{cases}$	$N^{x}\begin{cases}H\\Et\\Et\end{cases}$	$N^{x}\begin{cases}Et\\Et\\Et\end{cases}$	$N^{x}\begin{cases}Et\\Me\\Ph\end{cases}$ &c. &c.

in, in ninety-nine cases out of a hundred, the quantity of ammonia which is the t or resultant of a reaction, must contain 3 or some multiple of 3 atoms of rogen. Thus when ammonia results from the hydrogenation of nitric acid, we in, for every molecule of nitric acid containing 1 atom of hydrogen, a quantity of onia containing 3 atoms; and when ammonia reacts with benzoic chloralde- to form benzamide and sal-ammoniac, we require, for every molecule of benzoic raldehyde decomposed, a quantity of ammonia containing *twice* 3 atoms of hydrogen, H^6; and so in other instances. In the great majority also of compounds which onia forms directly with other bodies, the quantity of combining ammonia must essarily be represented with 3 or some multiple of 3 atoms of hydrogen. Thus the le molecule of aldehyde unites with $N^{x}H^3$, and the single molecule of nitrate of er with $2N^{x}H^3$. &c. Express these combinations or reactions how we please, we not represent them save with a proportion of ammonia containing 3 or some mul- of 3 atoms of hydrogen; and ninety-nine cases out of a hundred will yield the same lt. In those few exceptional cases in which the combining or reacting ammonia need necessarily be represented with 3 atoms of hydrogen, it may be, and we contend ought e, so represented. Thus when ammonia is decomposed by excess of chlorine, the re- on might be expressed, thus $\overset{x}{N}^{3}H + Cl^2 = \overset{x}{N}^{3}Cl + HCl$: but it is quite certain that the molecule of chloride of nitrogen contains 3 at. of chlorine, and consequen the reaction by which it is produced ought to be expressed thus: $N''' H^3 + Cl^6$ $N''' Cl^3 + 3HCl$; and so in other instances.

The same class of chemical reasons which induce us to regard marsh-gas as tet hydric and ammonia as trihydric, also induce us to regard water as dihydric. In wa we can replace one-half or two-halves of the hydrogen, but we cannot replace one-th or two-thirds as in ammonia, or one-fourth or three-fourths as in marsh-gas. If act upon water $O'' H^2$ by metallic potassium, we displace one-half its hydrogen to fo the very definite body *hydrate of potassium* $O'' KH$; and if we act upon hydrate potassium by potassium, we displace the other half of the hydrogen and form *oxide potassium* $O'' KK$. Or instead of introducing a second atom of potassium, we m turn out the first one. Thus if we treat hydrate of potassium $O'' KH$ with iodide ethyl we obtain *alcohol* $O'' EtH$, or we put a molecular grouping called ethyl in place of the potassium, which displaced one-half the hydrogen of the water. No we act upon the alcohol thus formed by potassium, it behaves exactly as did hydrate of potassium, or in other words it yields the remaining half of the origi hydrogen in exchange for potassium, and we obtain *ethylate of potassium* $O'' EtK$. we now act upon this new body by the iodide of methyl or ethyl, we turn out potassium representing one-half the original hydrogen and obtain *ethylate of me* $O'' EtMe$, or *ethylate of ethyl* $O'' EtEt$.

Again, in ninety-nine cases out of a hundred, the quantity of water, which is agent or resultant of a reaction must contain 2 or some multiple of 2 atom hydrogen. Thus, whenever an alcohol, ketone, or any definite organic substa yields a hydrocarbon or other compound by dehydration,—whenever an organic yields a pyroacid, or other pyrogenous product by dehydration,—whenever a sal ammonia, phenylamine, or other volatile alkali loses water,—and whenever two c pounds act upon one another to form a new body with simultaneous eliminatio water, whether the action be that of an acid upon a hydrocarbon, of an acid upon alcohol, of an acid upon an alkali, of an acid upon an acid, of an acid upon an aldeh of an alkali upon an aldehyde, or of an alkali upon an alcohol,—the quantity water eliminated inevitably contains 2, or some multiple of 2 atoms of hydro Moreover whenever a conjugated compound or diameride, a chloraldehyde, an orga metallic body, &c. &c., is decomposed by water, the quantity of water which re must necessarily be represented with 2 or some multiple of 2 atoms of hydro For example, when water reacts with hippuric acid to form benzoic acid and glycoc for every molecule of hippuric acid decomposed, we require a quantity of water c taining $O'' H^2$. When glycerin becomes acrolein by dehydration, for every mole of glycerin decomposed we obtain a quantity of water containing $2O'' H^2$. W nitric acid reacts with naphthalene to form nitro-naphthalene, for every molecul nitric acid which reacts, we have eliminated a quantity of water containing O'' When acetate of ammonia becomes cyanide of methyl by loss of water, for ev molecule of the salt decomposed, we liberate a quantity of water containing $2O'' H^2$; so in an infinite number of other instances. Again, in the majority of direct compou which water forms with other bodies, the combining water must be represented two atoms, or some multiple of two atoms of hydrogen. Thus the molecule of glu differs from that of fructose, and that of lactine differs from that of dextrine by addition of $O'' H^2$. The molecule of turpentine becomes hydrated turpentine absorbing $3O'' H^2$, and so in many other instances. The water of crystallisatio the great majority of hydrated salts must be represented with 2 atoms, or s multiple of 2 atoms of hydrogen. Thus the molecules of chloride of barium, nitrat mercurosum, and chloride of copper, crystallise with $O'' H^2$; the molecules of nit of cadmium, chloride of manganese, and nitrate of calcium with $2O'' H^2$; the m cules of chloride of calcium, nitrate of magnesium, and acetate of sodium with $3O''$ the molecules of microcosmic salt and hydrate of barium with $4O'' H^2$; the molecul borax with $5O'' H^2$; the molecules of chloride of aluminium and potassio-sulphat nickel, with $6O'' H^2$; the molecule of common arsenate of sodium with 7 or 12 O'' and the molecules of alum and rhombic phosphate of sodium with $12O'' H^2$, &c. There are some comparatively few salts, the acetate of barium, for example, in wh the water of crystallisation might be represented by $\frac{1}{2}O'' H^2$, or by $1\frac{1}{2}O'' H^2$, &c., none in which it need be so represented; while there are scarcely any reactions in wh the resulting or reacting water could possibly be expressed by $\frac{1}{2}O'' H^2$ or $1\frac{1}{2}O'' H^2$, none in which it would be correctly so expressed.

We have mentioned above that the quantity of carbon which unites with f separable portions of hydrogen to form marsh-gas, also unites with two separ portions of oxygen to form carbonic anhydride. Now each of these separable porti of oxygen is identical with the quantity of oxygen O'', which unites with 2 part hydrogen to form water.

stly, when we come to examine **hydrochloric acid**, we are unable to show that ydrogen is divisible, and we consequently look upon its molecule as containing but tom, or one indivisible proportion of hydrogen; whence we represent the com- d by the formula $Cl^{\blacksquare}H$; and we may anticipate here by remarking, that all ical evidence tends to show that the molecules of marsh-gas, ammonia, water, and hydric acid contain respectively four, three, two, and one atom of hydrogen.

addition to the class of binary hydrides, the atomic weights of the principal bers of which we have just considered, there is another large class of hydrogenised s, namely, the class of ternary or oxacids, the correct determination of whose cules is of the highest importance. The molecule of oxalic acid, for instance, may presented by the formula $C^{\blacksquare}HO^{2\times\blacksquare}$, or $C^{2\times\blacksquare}H^{2}O^{4\times\blacksquare}$, according as the acid is found monhydric or dihydric, monobasic or dibasic. Now the polybasicity of an acid not depend in any way upon the indivisibility of its formula, but solely upon its ession of certain specific characters; and the examination of the properties of oxalic soon shows us that its molecule must be represented, not by the more simple mono- , but by the more complex dibasic formula. In fact the same class of chemical ns which induce us to regard water as dihydric, must also induce us to regard c acid as dihydric, and so in other instances. Inasmuch as the modes of dis- ishing between monobasic, dibasic, tribasic, and tetrabasic acids have been tely set forth in the article ACIDS, it is unnecessary here to repeat them. We only observe that certain special acids, to the properties and metamorphoses of h we shall presently have occasion to advert, are proved by their specific charac- to be dihydric and dibasic, namely:

Carbonic acid	$H^{2}C^{\blacksquare}O^{3\times\blacksquare}$
Oxalic acid	$H^{2}C^{\blacksquare}O^{4\times\blacksquare}$
Sulphurous acid	$H^{2}S^{\blacksquare}O^{3\times\blacksquare}$
Sulphuric acid	$H^{2}S^{\blacksquare}O^{4\times\blacksquare}$

e will now turn our attention to the atomic weights of the four elements with h the hydrogen of the four primary hydrides, whose atomic weights we have con- ed somewhat minutely, is combined; whereby it will appear that the quantities of on, nitrogen, oxygen, and chlorine which we have represented by the symbols $N^{\blacksquare}$, $O^{\blacksquare}$, and $Cl^{\blacksquare}$, respectively, constitute the atoms of these elements, or the lest indivisible proportions of them which can enter into chemical combination. begin with **carbon**: we wish to prove that 12 parts of that element, or the tity thereof which combines with 4 parts of hydrogen to form marsh-gas, is smallest proportion of carbon that can exist in a compound. We find in the place that the quantity of carbon contained in the great majority of carbon-com- ds must necessarily be represented by 12, or some multiple of 12 parts. We may ce in illustration of this position, the primary series of homologous fatty acids and sodium-salts.

Formic .	$C^{1\times12}H^{2}O^{2\times\blacksquare}$	$C^{1\times12}H\ NaO^{\blacksquare\times2}$	. Formate
Acetic .	$C^{2\times12}H^{4}O^{2\times\blacksquare}$	$C^{2\times12}H^{3}NaO^{\blacksquare\times2}$	. Acetate
Propionic .	$C^{3\times12}H^{6}O^{2\times\blacksquare}$	$C^{3\times12}H^{5}NaO^{\blacksquare\times2}$	. Propionate
Butyric .	$C^{4\times12}H^{8}O^{2\times\blacksquare}$	$C^{4\times12}H^{7}NaO^{\blacksquare\times2}$	. Butyrate
Valeric .	$C^{5\times12}H^{10}O^{2\times\blacksquare}$	$C^{5\times12}H^{9}NaO^{\blacksquare\times2}$	. Valerate
Caproic .	$C^{6\times12}H^{12}O^{2\times\blacksquare}$	$C^{6\times12}H^{11}NaO^{\blacksquare\times2}$	. Caproate

ratio of carbon to hydrogen in the sodium-salts, necessitates our expressing constituent carbon as a multiple of 12. The mere ratio of carbon to hydrogen in acids, would allow the carbon, in all of them, to be expressed satisfactorily by bers which are not multiples of 12, but of 6. Valeric acid, for instance, might be esented by the formula $C^{5\times6}H^{5}O^{\blacksquare}$; but the circumstance that one-tenth part of its ogen can be displaced by sodium prevents the possibility of our halving the ogen in its molecule, and consequently of our reducing its carbon from a multiple to a mere multiple of 6.

om the circumstance that all carbon-compounds must be represented with 12 , or some multiple of 12 parts of carbon, it follows that whenever two compounds from one another by the different proportions of carbon which they respectively ain, that difference amounts to 12 parts of carbon, or to some multiple of 12 parts. , *wood-spirit* consists of 16 pts. of oxygen, 4 pts. of hydrogen, and 12 pts. of on, whereas in *aldehyde* we have another 12 parts of carbon, and in *acrolein* two 12 parts of carbon in addition, so that the three bodies may be represented by espective formulæ:

$C^{1\times12}H^{4}O^{\blacksquare}$	Wood-spirit
$C^{2\times12}H^{4}O^{\blacksquare}$	Aldehyde
$C^{3\times12}H^{4}O^{\blacksquare}$	Acrolein

We are not acquainted with any bodies intermediate in composition between woo spirit and aldehyde, or between aldehyde and acrolein, nor have we any reason anticipate their formation at any future time. Again *toluene* contains 8 parts of hydrog united with seven times 12 parts of carbon; whereas *cinnamene* contains another 12 pa of carbon, and *naphthalene* three other 12 parts of carbon in addition, thus:

$C^{7\times12}H^{8}$	Toluene
$C^{8\times12}H^{8}$	Cinnamene
$C^{9\times12}H^{8}$	Wanting
$C^{10\times12}H^{8}$	Naphthalene

Now the probability amounts almost to a certainty that a hydrocarbon intermedi between cinnamene and naphthalene will be discovered, and that a hydrocarbon int mediate between toluene and cinnamene, or between cinnamene and the expected co pound, or between the expected compound and naphthalene will not be discovered. follows also that when carbon, plus some other element or elements, is added to taken from a body, the quantity of carbon added or subtracted is always 12 parts, some multiple of 12 parts. Thus the molecule of *sodium-ethyl* absorbs 12 parts carbon, plus some oxygen to form *propionate of sodium; aconitic acid*, by the los 12 parts of carbon, plus some oxygen, becomes *citraconic acid*; and *phthalic* acid, by loss of twice 12 parts of carbon, plus some oxygen, becomes *benzene*. Moreover those series of compounds known as homologous, the quantity of carbon in e successive member of the series increases by 12 parts, as shown in a preceding table the fatty acids and their sodium-salts. All chemists recognise the fact, which indeed indisputable, that the smallest increment or decrement of carbon that can effected in a compound is 12 times as great as the smallest quantity of hydrog that can be introduced into or displaced from a compound; so that if the entire serie carbon-compounds is to be represented by the simplest satisfactory formulæ, the atom smallest combining proportion of carbon must be represented as having 12 times weight of the atom or smallest combining proportion of hydrogen. But some chemi who from old association still accord to carbon the atomic weight 6, consider that carbon-compounds contain an even number of atoms of carbon, and that in the deco positions and recompositions of these compounds, two inseparable carbon-atoms always concerned. But if we understand the smallest inseparable or indivisible p portion of an element to constitute its atom, the conception of two inseparably as ciated atoms is clearly illogical. Two small atoms of carbon, having each the va 6, if they can never be separated from each other, must nececessarily constitute large atom of carbon having the value 12.

There are two well-known compounds of carbon, namely, carbonic oxide, and c bonic anhydride, which may possibly be regarded as constituting exceptions to so of our previously made assertions. Thus the molecules of these two bodies may represented by one or other of the following pairs of formulæ:

$C^{1\times6}O^{1\times8}$	Carbonic oxide	$C^{1\times12}O^{1\times16}$
$C^{1\times6}O^{2\times8}$	Carbonic anhydride	$C^{1\times12}O^{2\times16}$

Now provided we recognise the dibasicity of the carbonic, oxalic, and other similar aci as their chemical properties require us to do, it is quite certain that a proportion of eit carbonic oxide or carbonic anhydride, containing only 6 parts of carbon, is incapa of effecting, or of resulting from, a definite chemical reaction. Carbonic anhydride particular, is a very frequent product of chemical action, but in no definite decompo tion do we ever obtain a smaller proportion of the gas than that represented by parts of carbon plus 32 of oxygen. A few illustrations are appended of the formation carbonic oxide and carbonic anhydride, from the decomposition by heat of three mo basic acids, namely, the formic, acetic, and benzoic; of two dibasic acids, namely, oxalic and tartaric; and of one tribasic acid, namely, the aconitic, the decomposit of which last has been before referred to.

Formic acid . $C^{1\times12}H^{2}O^{2\times16} = C^{1\times12}O^{1\times16} + H^{2}O$

Acetic acid . $C^{2\times12}H^{4}O^{2\times16} = C^{1\times12}O^{2\times16} + C^{1\times12}H^{4}$

Oxalic acid . $C^{2\times12}H^{2}O^{4\times16} = C^{1\times12}O^{1\times16} + C^{1\times12}O^{2\times16} + H^{2}O$

Benzoic acid . $C^{7\times12}H^{6}O^{2\times16} = C^{1\times12}O^{2\times16} + C^{6\times12}H^{6}$

Tartaric acid . $C^{4\times12}H^{6}O^{6\times16} = C^{1\times12}O^{2\times16} + C^{3\times12}H^{4}O^{3\times16} + H^{2}O$

Aconitic acid . $C^{6\times12}H^{6}O^{6\times16} = C^{1\times12}O^{2\times16} + C^{5\times12}H^{6}O^{4\times16}$.

With regard to nitrogen, all chemists are agreed that 14 parts of that eleme or the quantity thereof which combines with 3 parts of nitrogen to form ammonia the smallest proportion of nitrogen that can exist in a combination. We find that quantity of nitrogen contained in the great majority of nitrogenous compounds, cluding all salts of ammonia and of organic alkaloïds, must necessarily be represent t parts, or some multiple of 14 parts. Among miscellaneous bodies we may ce cyanogen, indigo, and nitric acid, each of which contains 14 parts of nitrogen; asparagin, and chrysammic acid, each of which contains twice 14 parts of nitro- creatine and carbazotic acid, each of which contains three times 14 parts of gen; uric acid and caffeine, each of which contains four times 14 parts of nitrogen, &c. From the circumstance that all nitrogenous compounds must be represented 14 parts of nitrogen, it follows that whenever nitrogen is liberated by a chemical ion, and whenever nitrogen plus some other element is introduced into a chemical ound, the quantity of nitrogen concerned must be represented by 14 parts or some iple of 14 parts. Thus by the action of nitric acid upon the hydrocarbons, and a great variety of other compounds, we can introduce into the compounds 14 parts, ice 14 parts, or three times 14 parts, &c. &c. of nitrogen, whereas we cannot duce any intermediate proportion. Again, when sal-ammoniac is decomposed hlorine, for every molecule of the salt decomposed, 14 parts of nitrogen are ated; and when nitrate of ammonia is decomposed by metallic zinc, for every cule of the salt decomposed twice 14 parts of nitrogen are liberated; so on. There are a few bodies formed on the type of one or more atoms of am- a, in which the ratios of the constituent elements might be satisfactorily expressed ormulæ in which the quantity of nitrogen represented was not a multiple of 14. trimercuramine might be represented by the formula $N^{1\times4\cdot7}Hg$, and tri- lamine, by the formula $N^{1\times4\cdot7}C^2H^5$. Similarly, all derivatives of ammonia in h the whole of the hydrogen is displaced by one and the same metal, hydrocarbon, alogen, might be represented by formulæ in which N = 4·7; which formulæ over, would be more simple than those in which N = 14. But the same class of ons which induces us to represent the molecule of ammonia with 3 atoms of ogen, induces us to represent the molecules of these bodies with 3 atoms of l, radicle, or halogen. Thus triethylamine is the third of a series of compounds, ly, $N^{1\times14}H^2(C^2H^5)$, $N^{1\times14}H^1(C^2H^5)^2$, and $N^{1\times14}(C^2H^5)^3$, obtained successively by tinuance of the same reaction. Moreover, a quantity of triethylamine containing than 14 parts of nitrogen, is not sufficient to effect any decomposition, or to ine with the molecule of any acid or salt. It is observable that the entire series mpounds is represented most simply by formulæ, in which N = 14, although one cular member of the series may be represented most simply by a formula in which 4·7.

t us now direct our attention to oxygen. We wish to show that 16 parts at element, or the quantity thereof which unites with 2 atoms of hydrogen to water, is the smallest proportion of oxygen that can enter into a combination. ind in the first place that the quantity of oxygen contained in the great majority efinite oxidised compounds, must necessarily be represented by 16 or some mul- of 16 parts. Thus the molecules of all hydrates, double oxides, acids, alts, aldehydes, ketones, alcohols, oxacid-ethers, and a great number variety of other compounds, doubtless forming together 99 per cent. of all known ounds of oxygen, cannot be represented save with 16 parts, or some multiple of arts of oxygen. For example, the molecules of *hydrate of potassium*, *benzoic yde*, *acetone*, *chloral*, *hypochlorite of sodium*, &c. &c. each contain 16 parts of en. The molecules of *spinelle*, *brown-hæmatite*, *camphor*, *benzile*, *acetate of sodium*, *ic acid*, &c. &c. each contain twice 16 parts of oxygen. The molecules of *nitric glycerin*, *chlorate of potassium*, *salicylic acid*, *augite*, &c. &c. each contain three s 16 parts of oxygen. The molecules of *phosphate of sodium*, *perchloric ether*, *et*, *olivine*, *sulphovinic acid*, &c. &c. each contain four times 16 parts of oxygen. molecules of *starch*, *acid malate of lead*, *nitrosalicylic acid*, &c. &c. each contain times 16 parts of oxygen. The molecules of *mannite*, *cream of tartar*, &c. &c. each in six times 16 parts of oxygen, while the molecules of *citric acid*, *pyrophosphate pper and sodium*, &c. &c. contain each seven times 16 parts of oxygen, and so on. the circumstance that nearly all oxidised compounds must necessarily be repre- d with 16 or some multiple of sixteen parts of oxygen, it follows that when two s differ from one another in composition by the different proportions of oxygen h they respectively contain, that difference amounts to 16 parts or some multiple parts of oxygen, as is well seen in the two following series of bodies.

KCl	Chloride of potassium	C^2H^4	Ethylene
$KClO^{1\times16}$	Hypochlorite of potassium	$C^2H^4O^{1\times16}$	Aldehyd
$KClO^{2\times16}$	Chlorite of potassium	$C^2H^4O^{2\times16}$	Acetic acid
$KClO^{3\times16}$	Chlorate of potassium	$C^2H^4O^{3\times16}$	Glycolic acid
$KClO^{4\times16}$	Perchlorate of potassium	$C^2H^4O^{4\times16}$	Glyoxylic acid.

llows also that the quantity of oxygen which can be liberated by any reaction, and h, either alone or together with some other element, can be added to, subtracted

from, or displaced in a compound, must be 16 or some multiple of 16 parts. N
why this should be unless the 16 parts constitute an indivisible proportion or chem
atom, is quite inconceivable. We may adduce the following illustrations. E
molecule of nitrate of sodium decomposed by heat into oxygen and nitrite of sodi
yields 16 parts of oxygen. Each molecule of permanganate of potassium, decompo
by sulphuric acid into oxygen and manganese-alum, yields twice 16 parts of oxy
Each molecule of chlorate of potassium decomposed by heat into oxygen and chlo
of potassium, yields three times 16 parts of oxygen. Each molecule of pentachlo
of phosphorus, converted by treatment with water into phosphoric chloraldehyde
hydrochloric acid, acquires 16 parts of oxygen in exchange for an equivalent quan
of chlorine. Each atom of alcohol converted into aldehyde by oxidation, reacts w
16 parts of oxygen, and each atom of alcohol converted into acetic acid by oxidat
reacts with twice 16 parts of oxygen. Each molecule of bromacetic acid, converte
the action of water into glycolic acid, acquires 16 parts of oxygen and 1 part of hy
gen, in exchange for one atom of bromine. Each atom of benzene, converted by t
ment with nitric acid into nitrobenzene, acquires twice 16 parts of oxygen, and 14 p
of nitrogen, in exchange for one atom of hydrogen, and so on. But precisely as t
are some nitrogenised bodies which with the atomic weight of nitrogen = 4·7, ma
divided into thirds, and can thus receive simpler formulæ than with the atomic we
of nitrogen = 14; so are there some comparatively few oxidised bodies which.
the atomic weight of oxygen = 8, may be divided into halves, and can thus rec
simpler formulæ than with the atomic weight of oxygen = 16. We have seen, h
ever, that if the comparable molecules of nitrogenised bodies were correctly formul
they would all be represented more simply by formulæ in which N = 14, tha
formulæ in which N = 4·7; so it will appear that if the comparable molecule
oxidised bodies were correctly formulated, they would all be represented more si
by formulæ in which O = 16, than by formulæ in which O = 8. Those oxid
bodies in which the ratio of the oxygen to the other constituents can be satisfact
expressed by assigning to the oxygen a number which is not 16 or a multiple of
but only 8 or a multiple of 8, comprise most compounds in which the oxygen is un
with one kind of matter only, including all the simple metallic oxides. Thus in w
and lime, the ratio of the constituent oxygen to the hydrogen and calcium respecti
is as satisfactorily expressed by the formulæ $\mathrm{O}^{1\times 8}\mathrm{H}$, and $\mathrm{O}^{1\times 8}\mathrm{Ca}$, as by the form
$\mathrm{O}^{1\times 16}\mathrm{H}^{2}$, and $\mathrm{O}^{1\times 16}\mathrm{Ca}^{2}$. The only question is, which of these pairs of formulæ repres
the molecules of the two bodies. Now it is no more necessary to argue the point whe
$\mathrm{O}^{1\times 8}\mathrm{Ca}$, is the correct expression for the metallic oxide, lime, than it was to argue
point whether $\mathrm{N}^{1\times 4\cdot 7}\mathrm{Hg}$, was the correct expression for the metallic nitride, mer
amine. The accordance of a trihydric formula to ammonia, necessitates the accord
of a trimetallic formula to mercuramine, and in a precisely similar manner, the acc
ance of a dihydric formula to water necessitates the accordance of a dimetallic for
to lime. It may be observed, moreover. that many strictly comparable reactions ca
effected by means of water, hydrate of calcium, and lime respectively, and that in t
cases the quantities of the reagents can only be expressed by the formulæ $\mathrm{O}^{1\times 16}$
$\mathrm{O}^{1\times 16}\mathrm{HCa}$, and $\mathrm{O}^{1\times 16}\mathrm{CaCa}$. Again, in bodies analogous to ordinary ether and
homogeneous anhydrides, the ratio of the oxygen to the other constituents ma
satisfactorily represented by formulæ in which the proportion of oxygen is expresse
8 parts only. Thus ether may be represented by the formula $\mathrm{O}^{1\times 8}\mathrm{Et}$, and ben
anhydride by the formula $\mathrm{O}^{1\times 8}\mathrm{Bz}$; but all arguments founded on mode of forma
on reactions, on vapour-densities, on seriated position and properties, &c. tend to s
that the above formulæ are not correct expressions of the molecules of the bo
represented, which, like that of water, contain 16 parts of oxygen. Thus, ether is
of the following series of bodies: $\mathrm{O}^{1\times 16}\mathrm{HEt}$, ethylate of hydrogen, or alcohol; $\mathrm{O}^{1\times 16}$
ethylate of methyl; $\mathrm{O}^{1\times 16}\mathrm{EtEt}$, ethylate of ethyl or ether; $\mathrm{O}^{1\times 16}\mathrm{PrEt}$, ethyla
propyl; and benzoic anhydride is one of the following series: $\mathrm{O}^{1\times 16}\mathrm{HBz}$, benzoa
hydrogen, or benzoic acid; $\mathrm{O}^{1\times 16}\mathrm{BzBz}$, benzoate of benzoyl, or benzoic anhyd
$\mathrm{O}^{1\times 16}\mathrm{AcBz}$, benzoate of acetyl, or aceto-benzoic anhydride; &c. &c. Lastly, in ce
dibasic acids and their salts of one metal, the ratio of the oxygen to the other
stituents may be satisfactorily expressed by monobasic formulæ, in which the oxyg
expressed not as a multiple of 16, but as a multiple of 8. Thus sulphurous acid

sulphite of sodium may be formulated as follows: $\mathrm{HS}^{\frac{=}{2}}\mathrm{O}^{3\times 8}$, and $\mathrm{NaS}^{\frac{=}{2}}\mathrm{O}^{3\times 8}$, re
tively. But as we have before observed, the distinctions between monobasic and
basic acids and their salts are very decided; and inasmuch as these acids and salt
indisputably dibasic (see ACIDS), their molecules cannot be correctly represente
monobasic formulæ. The simplest dibasic formulæ for carbonates, sulphites, and
phates respectively, are the following, in which the proportion of oxygen is neces
expressed as a multiple of 16 parts:

$H^2CO^{3\times16}$	$H^2S\cdot O^{3\times16}$	$H^2S\cdot O^{4\times16}$
$CaHCO^{3\times16}$	$NaHS\cdot O^{3\times16}$	$KHS\cdot O^{4\times16}$
$Ca^2CO^{3\times16}$	$Na^2S\cdot O^{3\times16}$	$K^2S\cdot O^{4\times16}$
$MgCaCO^{3\times16}$	$NH^4NaS\cdot O^{3\times16}$	$NiKS\cdot O^{4\times16}$

any chemists, who acknowledge that the molecule of water consists of 2 parts of rogen united with 16 pts. of oxygen, and that, in ninety-nine cases out of a dred, the smallest quantity of oxygen that can enter into the composition of a well-ned molecule must be represented by 16 parts, prefer, from old association, to rd to oxygen the atomic weight 8, and to admit that all oxygenated molecules ain two inseparably associated atoms of oxygen, or some multiple of two inseparably ciated atoms. Thus, they represent water by the formula $H^2O^{2\times8}$ instead of H^2O, nitric acid by $HNO^{6\times8}$ instead of HNO^3, &c. This practice is evidently most nsequent: for the conception of two inseparable proportions of 8 each, amounts r all to that of one indivisible proportion of 16, that is to an atomic proportion of To be consistent, we must represent the molecules of hydrochloric acid, water, onia, and marsh-gas either by Gerhardt's atomic, or by Dalton's equivalent ulæ, thus:

$HCl^{1\times35\cdot5}$	Hydrochloric acid	$HCl^{1\times35\cdot5}$
$H^2O^{1\times16}$	Water	$HO^{1\times8}$
$H^3N^{1\times14}$	Ammonia	$HN^{1\times4\cdot7}$
$H^4C^{1\times12}$	Marsh-gas	$HC^{1\times3}$

pt that Dalton took, not marsh-gas, but olefiant-gas, for his standard hydrocarbon, accorded to it the formula $HC^{1\times6}$, whereby marsh-gas became $H^2C^{1\times6}$. Now-a-s we know that the molecules of marsh-gas and olefiant-gas both contain the same ber of hydrogen-atoms, and that their formulæ are $C^{1\times12}H^4$ and $C^{2\times12}H^4$ respec-ly.

ith regard to chlorine, all chemists are agreed that 35·5 parts of that element, or quantity thereof which unites with 1 part of hydrogen to form hydrochloric acid, is smallest quantity of chlorine that can enter into a combination. We find that parts of chlorine are capable of directly displacing 1 part of hydrogen in a great ety of compounds; that in all well defined molecules, the quantity of constituent rine must be represented by 35·5, or some multiple of 35·5 parts; that whenever bodies differ from one another in composition by the quantity of chlorine they ectively contain, the difference amounts to 35·5, or some multiple of 35·5 parts; that it is impossible to add to, subtract from, or displace in any compound a pro-ion of chlorine which is not represented by 35·5, or some multiple of 35·5 parts.

the course of the preceding observations, reference has occasionally been made to principle of analogy as a guide in determining the molecule of a compound body, the atomic weights of its constituent elements. Thus we have referred to the ogy of triethylamine with ammonia, and to that of lime or oxide of calcium with er or oxide of hydrogen. But, in addition to the arguments already used, we show more especially that the principle of analogy is in favour of the atomic ghts and molecules which we have adopted. Thus the indisputable analogies of ous acid, nitric acid, and peroxide of nitrogen, with chlorous acid, chloric acid, peroxide of chlorine respectively, are shown very clearly by formulæ in which = 14, whereas they would be concealed by formulæ in which N = 4·7, as seen w:

Chlorous acid,	$HClO^2$	HNO^2	Nitrous acid	HN^3O^2
Chloric acid,	$HClO^3$	HNO^3	Nitric acid	HN^3O^3
Perchloric oxide,	Cl^2O^4	N^2O^4	Pernitric oxide	N^6O^4

gain, with the molecule of water = 9, the relation of water to the alcohols as the oubted vanishing term of the series, would not be manifested as it is with the ecule = 18. Thus, if we write alcohol $C^2H^6O^{2\times8}$, wood-spirit $CH^4O^{2\times8}$, and water $^{1\times8}$, the relation of water to the alcohols does not appear, but in the following s of formulæ with O = 16, it is perfectly apparent:

$C^5H^{12}O$, Amylic alcohol	C^2H^6O, Ethylic alcohol
$C^4H^{10}O$, Butylic „	CH^4O, Methylic „
C^3H^8O, Propylic „	H^2O, Hydric „

he relation of water to the alcohols, as shown in the above formulæ, is not a mere er relation, but has its foundation in experiment. When water and alcohol re-tively are acted upon by potassium, by chloride of benzoyl, by pentachloride of sphorus, and by a host of other reagents, the reactions are acknowledged by all to recisely similar. All chemists, no matter what the formulæ they employ, recognise fact that the quantity of water which in a reaction corresponds to one proportion lcohol, must contain two units of hydrogen. Similarly, with regard to hydrated bases and acids. The reactions of the bodies clearly show that the quantity of wat which corresponds to one proportion of hydrate of potassium, or of hypochlorous aci for instance, must contain two units of hydrogen. If we write hydrate of potassiu $KHO^{2\times8}$, hypochlorous acid $HClO^{2\times8}$, and water $HO^{1\times8}$, the formulæ do not repr sent comparable quantities. But, in the following series of formulæ with O = 16, t relations of the bodies are rendered perfectly evident:

KKO, Oxide of potassium	HClO, Hypochlorous acid
KHO, Hydrate of potassium	ClClO, Hypochlorous anhydride
HHO, Water	KClO, Hypochlorite of potassium

Moreover the principle of analogy is frequently allowed to overrule all other co siderations. Thus the smallest quantity of aluminium that can enter into a comb nation is 27·5 times as great as the smallest quantity of hydrogen. This quantity aluminium, like 14 parts of nitrogen, is capable of uniting with 3 atoms of chlorine, a of its representatives. But, from the strong analogy existing between aluminic a ferric compounds, the atomic weight of aluminium is fixed at 13·75, in order that compounds may be represented by formulæ which, though more complex than tho with Al = 27·5, are in accordance with the formulæ of corresponding ferric compoun thus:

Fe^2Cl^3,	Sesquichloride of iron
$KFe^2(SO^4)^2 . 12H^2O$,	Iron alum
HFe^2O^2,	Brown hæmatite
Al^2Cl^3,	Sesquichloride of aluminium
$KAl^2(SO^4)^2 . 12H^2O$,	Common alum
HAl^2O^2,	Diaspore

The principle of analogy frequently enables us to determine satisfactorily t molecules and atomic weights of bodies with which we are comparatively but litt acquainted. Thus the analogy of selenium and tellurium compounds, in so far as the are known, to the well-known compounds of sulphur, requires us to give simil formulæ to the similar compounds of all three elements. With regard to sulph itself, precisely the same reasons that induce us to represent water by the formu H^2O, and to accord to oxygen the atomic weight 16, must induce us to represent su phydric acid by the formula H^2S, and to accord to sulphur the atomic weight 32. B even if our acquaintance with sulphur were much less intimate than it is, still t analogy of its best known compounds with those of oxygen would suffice to allow of satisfactory determination of its atomic weight. The principle of analogy induces to accord to the primary hydrides and chlorides of the more or less electronegati elements, the following formulæ, and to classify them in four principal groups, thus

Monatomic.	Diatomic.	Triatomic.		Tetratomic.
HF	H^2O	H^3N	Cl^3N	H^4C
HCl	H^2S	H^3P	Cl^3P	H^4Si
HBr	H^2Se	H^3As	Cl^3As	Cl^4C
HI	H^2Te	H^3Sb	Cl^3Sb	Cl^4Si
ClI	Cl^2O		Cl^3Bi	Cl^4Sn
	Cl^2S			

The following table represents the atomic weights of the elementary bodies on th hydrogen scale (H = 1) as determined by the preceding considerations. Those on th oxygen-scale (O = 100), which are now but little used, may be found by multiplying th hydrogen-numbers by $\frac{100}{16}$ or 6·25. The actual determinations of the atomic weigh are given, with the methods of quantitative estimation, under each element.

TABLE OF ATOMIC WEIGHTS.*

Name.	Sym-bol.	Atomic Weight.	Formula of Compound analysed.	According to Experi-ments by
Aluminium† . . .	Al	13·75	Chloride of aluminium, Al^2Cl^3	Dumas.
Antimony . . .	Sb	120·3 122	Trisulphide, Sb^2S^3 Trichloride, $SbCl^3$	Schneider. Dumas.
Arsenic	As	75	„ $AsCl^3$	Pelouze, Berzelius.
Barium†	Ba	68·6	Chloride, BaCl	Marignac, Pelouze.
Bismuth	Bi	210	„ $BiCl^3$	Dumas.
Boron	B	11	Boric anhydride, B^2O^3 „ chloride, BCl^3	Berzelius. Dumas.

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* The metals marked † are now regarded as having atomic weights double of those assigned to them this table: e. g. Al = 27·5; Ba = 137·2; Pt = 198, &c. See pp. 470, 1008 of this volume; also iii. 96 963 and 968-975; and the article 'ATOMICITY' in the SUPPLEMENT.

TABLE *continued.*

Name.	Symbol.	Atomic Weight.	Formula of Compound analysed.	According to Experiments by:
omine	Br	80	Bromide of potassium, KBr	Marignac.
dmium†	Cd	56	Oxide, Cd^2O	Von Hauer.
lcium	Ca	20	Lime, Ca^2O	Erdmann and Marchand.
rbon	C	12	Carbonic anhydride, CO^2	Dumas and Stas. Erdmann and Marchand.
rium†	Ce	46	Cerous oxide, Ce^2O	Marignac, Hermann.
lorine	Cl	35·5	Chloride of potassium „ „ silver	Marignac, Penny; Maumené, Berzelius. Dumas.
romium†	Cr	26·2	Chromic anhydride, Cr^2O^3	Péligot, Berlin.
balt†	Co	29·5	Chloride, CoCl	Dumas.
obium or Columbium	Nb	94	Pentachloride, $NbCl^5$	Marignac.
pper†	Cu	31·7	Cupric oxide, Cu^2O	Erdmann and Marchand.
ymium†	Di	48	Oxide, Di^2O	Marignac.
bium	Eb	112·6	„ EbO	Bahr and Bunsen.
orine	F	19	Fluoride of calcium, CaF „ „ sodium, NaF	Louyet. Dumas.
ucinum†	Gl	4·7 7·0	Glucina, Gl^2O „ Gl^4O^3	Awdejew.
ld	Au	196	Auric chloride, $AuCl^3$	Levol, Berzelius.
drogen	H	1	Water, H^2O	Dumas; E. and M.
lium	In	75·6 113·4	Indic oxide, InO „ „ In^2O^3	Winkler.
ine	I	127	Iodide of potassium, KI „ „ silver, AgI	Marignac. Dumas.
dium†	Ir	98·6	Dichloride, $IrCl^2$	Berzelius.
n†	Fe	28	Ferric oxide, Fe^4O^3 Ferric chloride, Fe^2Cl^3	Svanberg and Norlin. Maumené; E. and M. Berzelius. Dumas.
nthanum†	La	46	Oxide, La^2O	Marignac.
ad†	Pb	103·6	„ Pb^2O	Berzelius.
hium	Li	6·5 7·0	„ Li^2O Carbonate, Li^2CO^3 Sulphate, Li^2SO^4	„ Troost. Mallet.
gnesium†	Mg	12	Magnesia, Mg^2O Chloride, MgCl	Berzelius. Dumas.
nganese†	Mn	27·6	„ MnCl	Berzelius.
rcury†	Hg	100	Mercuric oxide, Hg^2O	Erdmann and Marchand.
lybdenum†	Mo	46 48	Molybdic anhydride, Mo^2O^3	Svanberg and Struve; Berlin. Dumas.
ckel†	Ni	29 29·5	Oxide, Ni^2O Chloride, NiCl	Schneider. Dumas.
rogen	N	14	Sal-ammoniac, NH^4Cl	Pelouze, Marignac, Penny.
mium†	Os	100	Dichloride, $OsCl^2$	Berzelius, Frémy.
ygen	O	16		
lladium†	Pd	53	Chloride, PdCl	Berzelius.
osphorus	P	31	Phosphoric anhydride, P^2O^5 Pentachloride, PCl^5	Schrötter. Dumas.
tinum†	Pt	99	Dichloride, $PtCl^2$	Berzelius, Andrews.
tassium	K	39 39·2	Chloride, KCl	Marignac, Frémy, Maumené. Stas.
odium†	Rh	52	Sesquichloride, Rh^2Cl^3	Berzelius.
thenium†	Ru	52	„ „ Ru^2Cl^3	Claus.
enium	Se	79	Selenide of mercury, Hg^2Se	Berzelius, Sacc, Erdmann and Marchand.
licon	Si	28	Chloride, $SiCl^4$	Dumas.
ver	Ag	108	„ AgCl	Marignac, Maumené, Penny, Berzelius.
dium	Na	23	„ NaCl	Penny, Pelouze, Dumas.
rontium†	Sr	43·8	„ SrCl	Dumas.
lphur	S	32	Cinnabar, Hg^2S Sulphide of silver, Ag^2S	Erdmann and Marchand, Struve. Dumas.
ntalum	Ta	137·6 182	Tetrachloride, $TaCl^4$ Pentachloride, $TaCl^5$	H. Rose. Marignac.
llurium	Te	128	Bromide of potassium and tellurium, K^2TeBr^6	v. Hauer.
orinum†	Th	59·5	Thorina, Th^2O	Berzelius.
	Sn	116 118	Stannic oxide, SnO^2 „ chloride, $SnCl^4$	Mulder, Vlaanderen. Dumas.
anium	Ti	50	Tetrachloride, $TiCl^4$	Pierre.
ngsten†	W	92	Tungstic anhydride, W^2O^3	Schneider, Birch, Dumas.
anium†	U	60	Uranic oxide, U^4O^3	Péligot.
nadium	V	68·5 51·2	Vanadic anhydride, V^2O^3 „ „ V^2O^5	Berzelius. Roscoe.
ium	Y	61·7	Yttria, YO	Bahr and Bunsen.
c†	Zn	32·5	Oxide, Zn^2O	A. Erdmann.
conium	Zr	33·5 89·5	Zirconia, Zr^4O^3 „ ZrO^2	Berzelius, Erdmann.

e will now turn our attention to the determination of atomic weights from sical considerations, and observe how far the weights deduced from physical and nical considerations coincide with one another. In the first place, then, we will discuss the combining volumes of gases and vapours; from the observati which we derive the most important of all means for controlling our conclusions as the atomic weights of volatile bodies. If we take the specific gravity of hydrogen gas unity, we find experimentally that the specific gravities of most other elementary ga and vapours are represented by the numbers we have selected to express their ato weights. Hence, these atomic numbers represent the weights of equal volumes the respective gases and vapours; and the formula of a compound body shows number of elementary volumes of which it is composed. Thus while the formula nitric acid HNO^3 represents a compound of one part of hydrogen, fourteen parts nitrogen, and three times sixteen parts of oxygen, it also represents a compound of volume of hydrogen, one of nitrogen, and three of oxygen. The relative spec gravities of the following elements, when in the gaseous state, and exposed to same pressure and temperature, have been ascertained to be respectively:

H = 1 Cl = 35·5 O = 16 N = 14
Hg = 100 Br = 80 S = 32 P = $\frac{31}{2}$
Cd = 56 I = 127 Se = 79·5 As = $\frac{75}{2}$

Hydrochloric acid gas is composed of one volume of hydrogen, and one volume chlorine united without any condensation. Consequently the molecule of hydrochlo acid is represented by two volumes of gas ◻◻, whilst the atoms of hydrogen chlorine respectively are represented by one volume only ◻. Hence while specific gravity, or weight of a unit of volume of chlorine coincides with its ato weight, the specific gravity or weight of a unit of volume of hydrochloric acid co cides with the half of its atomic weight, $\frac{1 + 35·5}{2} = 18·25$. Now ninety-nine per ce of all known volatile compounds agree with hydrochloric acid in this particul namely, that their specific gravities in the gaseous state are the halves of their ato weights. Thus the atomic weight of water $H^2O^{1\times16}$, being 18, one volume of ste is found to be 9 times as heavy as one volume of hydrogen. The atomic weight ammonia, $H^3N^{1\times14}$, being 17, one volume of ammoniacal gas is found to be 8·5 tin as heavy as one volume of hydrogen. The atomic weight of marsh-gas, H^4C^1 being 16, one volume of the gas is found to be 8 times as heavy as one volume hydrogen, and so forth. Inasmuch, therefore, as half the atomic weight coinci with the specific gravity, or weight of one unit of volume, the entire atomic wei must represent *twice* the specific gravity, or the weight of two units of volume; a c clusion which may be confirmed by actual experiment. Thus one volume of oxyg and two volumes of hydrogen at the temperature 100° C. can be converted into volumes of steam at the temperature 100°. Again two volumes of ammonia, wh decomposed by the transmission of a series of electric sparks, yield one volume nitrogen, and three volumes of hydrogen. No matter what the number of atoms volumes which enter into the constitution of any volatile compound, they all beco condensed into two volumes, as shown by the fact that the specific gravity or vapo density of the compound is the half of its atomic weight.

Seeing that the molecule of a compound body corresponds with two volumes of or vapour, and the atom of an element with but one volume, it is evident that quantity of an element which is strictly comparable to the molecule of a compound b must be represented by two atoms. Hence the symbols |H|H|, |H|Cl|, and |Cl| represent comparable quantities of the three bodies, hydrogen, hydrochloric a and chlorine respectively which, thus formulated, present an obvious relation sequence to one another. By the molecule of an element, therefore, we invaria understand two atoms or two volumes; and there is great reason to believe that acquaintance with the uncombined elements pertains exclusively to their molecu So that while Cl, for instance, represents the atom, or smallest proportion of chlo that can enter into a combination, Cl^2 represents the molecule or smallest proport of free chlorine that can result from or effect a reaction. There are certain c pound molecular groupings also, which like the elementary molecules, occupy volumes when in the free state, and become halved in combination. Thus ethyl in free state is represented by C^4H^{10} = ◻◻, in the combined state by C^2H^5 = ◻, so in other instances.

It is evident from the preceding observations that, in the great majority of instan the molecules we have deduced from chemical considerations, are identical with molecules deduced from the physical law of gaseous volumes enunciated by Amp namely, that all gases contain the same number of molecules within the same volu But if we had represented water by the formula $HO^{1\times8}$, sulphydric acid by formula $HS^{1\times16}$, and carbonic oxide by the formula $C^{1\times6}O^{1\times8}$, we should h represented their molecules as having only half the volume of the molecule of hyd chloric acid, and should consequently have violated Ampère's physical law. T eral conclusions at which we have arrived, however, namely that the chemical atoms lementary bodies correspond with one gaseous volume, and the chemical molecules simple or compound bodies, with two gaseous volumes, is quite in accordance with sical requirements. Nevertheless there are some exceptions, real or apparent, to ich we must now direct our attention. We may premise by saying that some mists attach so great an importance to the law of volumes, that they would be ded exclusively by it, and would accord to all bodies whatsoever, such atomic ghts as would be in accordance with it. In the present state of knowledge, however, eems to us preferable to deduce the chemical atom or molecule of a body chiefly n chemical considerations, and to wait for further investigation to clear up the few malies which at present exist between the results of chemical and physical inquiry. ertain apparent exceptions to the law of volumes have of late years been satisorily explained away, by having regard to the following habitudes of volatile ies. In the first place, some vapours, at temperatures but little raised above their densing points, have anomalous densities which are much too high, or, in other ds, the volumes of their atomic proportions are much too small; whereas at higher peratures their densities and volumes are perfectly normal. Thus at a temperature ttle above its condensing point, an atomic proportion of sulphur vapour occupies y $\frac{1}{3}$ the bulk of an atomic proportion of hydrogen gas at the same temperature; but the temperature 1000° C. the two atomic proportions occupy the same volume. in the molecule of acetic acid vapour at the temperature 230° C. has the same me as the molecule of hydrochloric acid gas at that temperature; but at lower peratures, its volume decreases almost to one-half that of hydrochloric acid gas at same temperatures. In reference to this property it must be borne in mind that ours near their condensing points manifest variations from several of the physical s affecting gases. It would seem, indeed, that a vapour must be heated to a temture considerably above its condensing point before it acquires the properties of a fect gas. The recognition of this circumstance enables us to account in several ances for those departures from Ampère's law, in which the density of the gas is high. In the second place, several compounds at the high temperatures required ring them into a perfectly elastic state, seem to undergo a change, which has been estigated by Kopp, Marignac, Deville, Hofmann, Kékulé and others, and has been ned *disassociation*. According to these investigators, the molecule of a volatile pound, when strongly heated, sometimes breaks up into two simpler molecules ch, on a reduction of temperature, reunite to form the original body, so that at temperature at which the density is taken, we are really operating, not upon one e complex, but upon two less complex molecules; whence the densities are found to espond with four volumes of vapour instead of with only two. The anomalous mes or densities of the following compounds have been explained in this way.

	4 Vols		2 Vols.		2 Vols.
Sal-ammoniac	NH^4Cl	=	NH^3	+	HCl.
Sulphuric acid	H^2SO^4	=	SO^3	+	H^2O.
Pentachloride of phosphorus . .	PCl^5	=	PCl^3	+	Cl^2.
Hydrate of ethylendiamine . . .	$C^2H^{10}N^2O$	=	$C^2H^8N^2$	+	H^2O.

he phenomenon of disassociation then frequently enables us to explain various artures from Ampère's law, in which the densities are too low; or in which, in r words, the volumes are too great. But there still remain certain exceptions, ch, in the present state of knowledge, cannot be satisfactorily explained by either he above described considerations. Thus the atomic volumes of the vapours of sphorus and arsenic respectively, are only one-half that of hydrogen. In order to e their atomic weights correspond with their atomic volumes, the ordinarily reed atomic weights would have to be doubled, whereby they would become 62 and respectively. But this doubling of the atomic weights of phosphorus and arsenic ld be in violation of all chemical considerations, and likewise of all physical consitions except that relating to the atomic volumes of the elements themselves. Thus formula for phosphamine would become $P^{1\times62}H^6$, and that for arsenamine $^{150}H^6$, despite the analogy of the two compounds to ammonia NH^3, and despite fact that the hydrogen of the two compounds is divisible into thirds only and into sixths. Moreover the vapour-densities of the compounds $P^{1\times62}H^6$ and $^{150}H^6$ would correspond to 4 volumes instead of 2, and would consequently be pposition to Ampère's law. Again, the atomic heats of phosphorus and arsenic esponding to the atomic weights 62 and 150 respectively, would be twice as high he highest atomic heat of any other element. Lastly, by doubling the atomic ghts of arsenic and phosphorus, the isomorphism of certain compounds of ammonia the corresponding compounds of phosphamine and arsenamine would become telligible. At present then we are forced to admit that the vapour-densities of the ents, phosphorus and arsenic, are anomalous, and that we are incapable of ex-

plaining the cause of the anomaly. It may be that the vapours of these elem
like that of sulphur, though anomalous at one temperature, become normal a
higher temperature, though it must be admitted that the recent experiments of Devil
do not countenance such an expectation. Or it may be that the anomalies depe
upon allotropy. Phosphorus and arsenic are known to exist in different allotrop
conditions, and it is not improbable that each allotropic form may have a differe
atomic weight. Hence the anomaly might be explained by supposing that phosph
mine, for instance, contains the element phosphorosum, having the atomic weight 3
whilst phosphorus-vapour is composed of the element phosphoricum, having t
atomic weight 62. This supposition of vapour-allotropy might also serve to expla
the anomolous vapour-density of acetic acid at a low temperature. Normal acetate
potassium has the formula $C^2H^3KO^2$, but there is also an acid-acetate having t
formula $C^4H^7KO^4$. The small vapour-density might possibly represent an acetic a
corresponding to the former salt, and the high vapour-density an acetic acid cor
sponding to the latter.

Certain other real or apparent exceptions to the law of volumes, are afforded by t
chlorides and ethylides of zinc, mercury, and some other metals, as indicated below

Hydrochloric acid . . .	HCl = 2 vols.	
Hydride of ethyl . . .	HEt „ „	
Chloride of ethyl . . .	$ClEt$ „ „	
Chloride of mercury . . .	$HgCl$ = 1 vol. or	Hg^2Cl^2 = 2 vols.
Ethylide of mercury . . .	$HgEt$ „ „ „	Hg^2Et^2 „ „
Ethylide of zinc	$ZnEt$ „ „ „	Zn^2Et^2 „ „
Methylide of zinc . . .	$ZnMe$ „ „ „	Zn^2Me^2 „ „

In consequence of the anomalous vapour-densities of the molecules of these co
pounds, as above expressed, some chemists have proposed to double the ordinar
received atomic weight of the metals mercury and zinc, so as to represent the molecu
of the above volatile compounds by the following 2-volume formulæ; and it must
acknowledged that very strong reasons may be urged in favour of the duplication:

	Chloride of mercury	$Cl^2Hg^{1\times200}$
	Ethylide of mercury . . .	$Et^2Hg^{\times200}$
	Ethylide of zinc	$Et^2Zn^{1\times65}$
	Methylide of zinc	$Me^2Zn^{1\times65}$
corresponding to	Hypochlorous oxide	$Cl^2O^{1\times16}$
	Water	$H^2O^{1\times16}$

It is admitted both by those who advocate and those who deprecate the proposal, t
the duplication of the atomic weights of the metals mercury and zinc, would neces
tate the duplication of the atomic weights of several other metals, including magnesi
cadmium, lead, copper, iron, chromium, and aluminium. Now the principal objecti
to the adoption of this proposal are the following. Firstly, because, although
duplication of the atomic weights of the metals would bring the volumes of t
chlorides and ethylides into accordance with Ampère's law, it would bring the volu
of the elements themselves into discordance therewith. Thus, the atomic volume
mercury and cadmium corresponding to the atomic weights 200 and 112 respectiv
would each be twice as great as the atomic volume of any other element. Secon
because the chlorides, oxides, &c., of these metals, which are ordinarily represen
as proto-compounds, would have to be represented as deuto-compounds, t
$HgCl^2$, $ZnCl^2$, $CdCl^2$, &c., a result not warranted by chemical considerations, seeing t
in their chemical properties, these compounds are quite undistinguishable from un
puted proto-compounds. Moreover, the adoption of these doubled atomic weig
would lead to most complex expressions for very many compounds. Of course, i
could be proved that the true atomic weights of these metals were really the double
those ordinarily employed, the circumstance of the duplication leading to inconven
formulæ would have to be disregarded; but in the absence of such proof, the c
plexity to which the conclusion would lead is *pro tanto* evidence against the pr
bility of its being true. Thus, phosphate of lead would become $Pb''^3P^2O^8$ instead
Pb^3PO^4; potassio-sulphate of copper would become $K^2Cu''(SO^4)^2.6H^2O$ instead
$KCuSO^4.3H^2O$; sulphovinate of zinc would become $Et^2Zn''(SO^4)^2.2H^2O$ instead
$EtZnSO^4.H^2O$; mercaptide of mercury would become $Et^2Hg''S^2$ instead of $EtHgS$, &c.

Other exceptions to Ampère's law are furnished by the sesquichlorides of alumini
iron, and chromium, the vapour densities of each of which, as determined by Dev
correspond to one volume of vapour only, instead of to two volumes. Hence it has b
proposed to double the weights of the molecules of these compounds, and to repre
them by the formulæ Al^4Cl^6, Fe^4Cl^6, and Cr^4Cl^6 respectively. But it is observ
that if the molecule of sesquichloride of aluminium really contains 6 atoms of chlo
it must also contain 55 parts of aluminium, and as a consequence, 55 parts of alu

will constitute the smallest combining proportion of the metal, or the smallest,
tity which ever exists in a combination; in which case the smallest combining pro-
on of aluminium will have twice the specific heat of the smallest combining propor-
of any other element, a result that must throw considerable doubt upon the
riety of the change on which it would be consequent. Again the vapour-density
chemical relations of chlorochromic aldehyde alike show that its molecule must
xpressed by the formula $Cr^2O^2Cl^2$; while the correlations of sesquichloride of
nium and chlorochromic aldehyde require the molecules of the two compounds to
presented by formulæ expressing the same amount of chromium, which would not
e case if the sesquichloride were represented by the formula Cr^4Cl^6. There is,
over, another compound, namely, arsenious anhydride, As^2O^3, the vapour-density
hich corresponds to only one volume of vapour instead of two volumes, although no
n for the anomaly has yet been brought forward. There are also three well-
n compounds, the vapour-densities of each of which correspond to four volumes,
ad of to only two, namely, nitric oxide, N^2O^2, pernitric oxide, N^2O^4, and perchloric
e, Cl^2O^4. In its chemical relations, the molecule of nitric oxide, N^2O^2, corresponds
e molecule of chlorine, Cl^2, and the atom of nitric oxide, NO, corresponds to the
of chlorine, Cl: but whilst the atom of chlorine corresponds to one volume, and
molecule of chlorine to two volumes, the atom of nitric oxide corresponds to
volumes, and its molecule to four volumes of gas, and similarly with pernitric
e and perchloric oxide. At present no satisfactory explanation has been given
nese anomalies, though it is not improbable that they may be explicable on
principle of disassociation. Thus, it is possible that the atom of sulphurous
dride, $(SO^2)''$, which, like that of oxygen, O'', is capable of displacing two atoms of
ogen, would also, like the atom of oxygen, be represented by one gaseous volume,
it not for the circumstance that the molecule of oxygen, O^2, cannot split into two
r molecules, whereas the molecule of sulphurous anhydride, S^2O^4, corresponding
eto in equivalency, can split into two separate molecules, each of which is capable
cupying two volumes; and this relation of oxygen to the diequivalent atoms of
hurous anhydride, sulphuric anhydride, carbonic oxide, carbonic anhydride, &c.,
be a parallel of the relation which subsists between chlorine and the prot-
valent atoms of nitric oxide, pernitric oxide, and perchloric oxide respectively.
t of many hundred volatile bodies whose vapour-densities have been ascertained, the
wing table comprises all the well-known exceptions to Ampère's law, though doubt-
the strict chemical analogues of some of these bodies would also prove exceptional:

ymbol.	Vapour.	Atomic weight.	Theoretical volume.	Actual volume.
	Phosphorus	P = 31	1	½
	Arsenic	As = 75	1	½
Cl	Corrosive sublimate	Hg = 100	2	1
Et	Mercuric ethyl		2	1
Me	Mercuric methyl		2	1
Et	Zinc-ethyl	Zn = 32·5	2	1
Me	Zinc-methyl		2	1
O^3	Arsenious anhydride	As = 75	2	1
Cl^3	Aluminic chloride	Al = 13·75	2	1
Cl^3	Ferric chloride	Fe = 28	2	1
Cl^3	Chromic chloride	Cr = 26·2	2	1
O^2	Nitric oxide	N = 14	2	4
O^4	Pernitric oxide		2	4
O^4	Perchloric oxide	Cl = 35·5	2	4
SO^4	Sulphuric acid	S = 16	2	4
H^4Cl	Sal-ammoniac	N = 14	2	4
H^4CN	Cyanide of ammonium	C = 12	2	4
$H^4.H.S$	Sulphydrate of ammonium	S = 32	2	4
l^5	Pentachloride of phosphorus	P = 31	2	4
$H^{10}N^2O$	Hydrate of ethylene-diammonium	C = 12	2	4
$H^{18}N^2O$	Hydrate of diethyl-ethylene-diammonium		2	4

The anomalous volumes of the last seven compounds are clearly explicable on the pri
ciple of disassociation. With regard to the duplication of the atomic weights of tho
metals whose chlorides and ethylides have anomalous densities, it must be remember
that the proposal is at present young, and that further investigation may suffice
remove some of the objections which at present surround it; precisely as further i
vestigation removed the objections which in the first instance seemed to oppose wi
overwhelming force, Gerhardt's proposal to double the then received atomic weights
carbon, oxygen, and sulphur. This same remark applies to the proposal of Canniza
which we shall next have to consider.

It was contended by Dulong and Petit, who were the earliest investigators on t
subject, that all elementary atoms have the same capacity for heat, or, in other wor
that the specific heats of all elementary atoms are the same. If this l
be admitted, it is obvious that the determination of the specific heat of an eleme
must furnish a ready means of fixing its atomic weight. The atomic heats of sim
and compound bodies have been of late years ascertained with great care, though fr
the nature of the subject it can scarcely be said with great accuracy, by Regnau
whose results, corresponding to the atoms which we have adopted, are as follows:—

12	Carbon	2·89	80	Bromine	6·74
32·5	Zinc	3·10	127	Iodine	6·87
56	Cadmium	3·16	32	Sulphur	6·48
13·75	Aluminium	2·93	79	Selenium	6·62
28	Iron	3·18	128	Tellurium	6·06
29·5	Nickel	3·20	31	Phosphorus	5·85
29·5	Cobalt	3·15	75	Arsenic	6·10
31·7	Copper	3·01	120·3	Antimony	6·09
100	Mercury	3·19	210	Bismuth	6·57
103·6	Lead	3·25	118	Tin	6·57
53	Palladium	3·15	23	Sodium	6·75
99	Platinum	3·19	39	Potassium	6·71
27·5	Manganese	3·1	108	Silver	6·16
26·2	Chromium		196	Gold	6·38
12	Magnesium				
20	Calcium				
43·8	Strontium				
68·6	Barium				

The numbers representing Regnault's atomic heats were obtained by multiplying t
observed specific heats of the bodies, referred to that of water as unity, by th
atomic weights on the oxygen scale. But it would be found more convenient in pr
tice to assume the atomic heat of lead, which corresponds nearly with the me
atomic heat, as unity; whereby the atomic heats of the first class of metals wo
approximate more or less closely to the number 1, and those of the second class
the number 2. On this scale, the specific heats of the first class elements would c
respond to the reciprocals of their atomic weights on either scale, and those of t
second class to twice their reciprocals.

At the time of Regnault's researches, the atomic weights of all the elements in t
second column, with the exception of sodium, potassium, and silver, were frequen
expressed by the halves of the numbers we have adopted. Regnault proposed to ha
the atomic weights of these three metals also, whereby the atomic heats of all t
elements would be in accordance with Dulong and Petit's law, and would be e
pressed by numbers approximating more or less closely to 3·0 on the water-un
scale, or to 1·0 on the lead-unity scale. It is observable that in no case does t
experimental atomic heat thus obtained differ from the mean atomic heat in the prop
tion of 1·1, or 0·9, to 1·0; whereas the extreme atomic weights differ from one anoth
in the ratio of 1 to 9. Concerning this close correspondence in the atomic heats of t
elements, Graham writes: "The law (of Dulong and Petit) would probably represe
the results of observation in a perfectly rigorous manner, if the specific heat of ea
body could be taken at a determinate point of its thermometrical scale, and if t
specific heat could be further disencumbered of all the foreign influences which mod
the observation," such as the original state of hardness or softness of the body,
crystalline or amorphous condition, the heat absorbed to produce softening, and t
heat absorbed to produce dilatation, &c. Recent chemical research, however, h
rendered it impossible for chemists to halve the atomic weights of the elements in t
second column, so as to make their atomic heats coincide with that of lead; and hen
Cannizzaro has been led to advocate a transposition of Regnault's proposal, so as to ma
tain the integrity of Dulong and Petit's law, by doubling the atomic weights of t
metals in the first column, whereby the atomic heats of all the elements, with t

sible exception of carbon, would be expressed by numbers approaching more or less
ely to 6.

annizzaro has also pointed out that if his atomic weights were adopted, the atomic
ts of many compound bodies, when divided by the number of their constituent
ns, would give a number approximating more or less closely to 6, or in other
ds, the atomic heats of these bodies approximate to the sum of the atomic heats
their constituent elements. It is observable, however, that the latter mode of ex-
ssing the fact applies equally well, whether or not we double the atomic weights in
first column. Thus the atomic heat of chloride of silver approximates to 6 + 6
12, and that of chloride of lead to 6 + 3, or 9.

t is evident that the atomic weights proposed by Cannizzaro, from considerations
pecific heat, frequently correspond with those which he and others have been led
rom considerations of atomic volume; and their adoption is consequently liable to
objections which we have already taken.

Cannizzaro's proposal, moreover, would involve the dissassociation of silver from
l, and that of the metals of the alkalis from those of the alkaline earths. The
orides of silver and potassium, for instance, would be represented as protochlorides
the formulæ AgCl and KCl respectively, whilst those of lead and barium
ld be represented as dichlorides by the formulæ $PbCl^2$ and $BaCl^2$ respec-
ly. Now the highly basic characters of the alkaline earth-metals, the strongly
line reactions of their dissolved hydrates, the perfect neutrality and great per-
ency of their salts, seem to demonstrate their analogy to undisputed protequiva-
metals, such as potassium, rather than to undisputed di-equivalent metals, such
tin. Again, the large number of similar compounds to which silver and lead give
in, the close resemblance in chemical properties of their corresponding compounds,
r very general paramorphism, and not unfrequent isomorphism, seems to forbid
r representation by discordant formulæ. The two metals are soft, malleable,
ble, volatile, and isomorphous. The two chlorides are anhydrous and insoluble,
sparingly soluble; the two sulphates are anhydrous, insoluble and similiform; the
hydrates are sparingly soluble, forming alkaline solutions; the two sodium-double-
orides, potassium-double-iodides, protosulphides, cuprosulphides, monobasic and
asic sulphantimonites, are similar in their chemical, and isomorphous in their
sical relations.

t seems to us that the objections to Cannizzaro's general proposition, are, in the
sent state of knowledge, too great to admit of its adoption;* but still it is a question
ether some of the metals comprised in the first column might not advantageously,
eive the doubles of their ordinarily admitted atomic weights. With regard to the
tals palladium and platinum, for instance, it is not by any means improbable
t their real atomic weights may prove to be 106 and 198 respectively. With
ard to aluminium, again, it is certain that, so far as our actual knowledge goes, the
llest indivisible proportion of aluminium that can exist in a combination is twice
proportion expressed by its ordinarily received atomic weight, or, in other words,
amounts to 27·5, instead of to only 13·75 parts. All chemists invariably represent
compounds of aluminium to contain 27·5 parts of aluminium, which is indeed its
allest combining proportion or chemical atom Consequently, by employing the num-
13·75 to express the atomic weight of aluminium, all aluminous compounds have to
represented as containing two inseparable atoms, or some multiple of two inseparable
ms of the metal, a result which is evidently unphilosophical. The chemical habitudes
he metal aluminium resemble the chemical habitudes of the metal bismuth, 27·5 parts
the former corresponding to 210 parts of the latter: and there is no greater chemical
son for halving the 27·5 parts of aluminium in order to represent its trichloride
a sesquichloride, than there is for halving the 210 parts of bismuth in order to
resent its trichloride as a sesquichloride. Somewhat similar observations apply to
metals, iron, manganese, and chrome, when entering into the constitution of
ic, manganic, and chromic salts, respectively. Throughout all the decompositions
l recompositions of ferric compounds, for instance, so long as they continue to be
ric compounds, we find 56 parts of iron constituting one indivisible combining pro-
tion or chemical atom. We have two allotropic forms of the metal iron, one of
ich we call *ferrosum*, having the atomic weight 28, the atomic heat 3, and combin-
with 1 atom of chlorine, to form a protochloride; — the other, which we call
ricum, having the atomic weight 56, the atomic heat 6, and combining with 3
portions of chlorine to form a trichloride; and similarly with *chromosum* and *chro-*
cum, *manganosum* and *manganicum*. The ferrous and ferric atoms have distinct
emical properties and form distinct series of compounds, which differ more from
another than do the salts of ferrosum from those of nickel and copper, or than do
salts of ferricum from those of aluminium and bismuth. So great, indeed, is the

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This opinion has since been modified by the writer. See METALS, ATOMIC WEIGHTS AND CLASSI-
ATION OF (iii. 958-963).

and ferric compounds into one another, we should never have suspected them t contain the same metal, or even similar metals. Now, that two different allotropi forms of the same element may have different atomic weights and different equivalent functions, seems to be no longer questionable. Brodie's reseaches on *graphon* have shown conclusively that compounds may be prepared which contain the graphiti modification of carbon, and are altogether dissimilar from compounds containing th ordinary form of carbon. In fact, ordinary carbon-compounds present a greate analogy to corresponding compounds of sulphur than they do to any of the know compounds of graphon, precisely as the salts of ferrosum resemble salts of nickel mor closely than they do the salts of ferricum. The only circumstance wanting to complet the parallel is that not only carbon and graphon compounds, but isolated carbon an graphon are known to chemists; whereas, though ferrous and ferric compounds are we known, chemists have not yet recognised any form of iron distinct from ferrosum unless indeed we make the by no means improbable assumption that iron in the passiv state constitutes ferricum. The specific heats of carbon, graphon, and diamond correspond clearly with different atomic weights. Thus, if we accord to carbon the atomi weight 12, to graphon the atomic weight 18, and to diamond the atomic weight 24, th atomic heats of the three bodies, calculating from Regnault's results, will be 2·898 3·6324, and 3·5232 respectively, giving a mean of 3·3512. But it seems probable fro chemical considerations that the atomic weight of graphon is not 18, but 36 (3 Brodie), in which case its atomic heat will be 7·2048, or exactly as much above th mean as that of phosphorus is below it.

Precisely as the double atoms of iron and aluminium in ferric and aluminic salt constitute indivisible proportions, so do the double atoms of copper and mercury i cuprous and mercurous compounds constitute indivisible proportions throughout a the decompositions and recompositions of their respective salts. So long as the metal remain in the state of *cuprosum* and *mercurosum*, so long do 63·5 parts of the forme and 200 parts of the latter constitute their respective atomic weights or smalle indivisible combining proportions. Each metal would have for its atomic heat th number 6, and would combine with one atom of chlorine to form a protochloride, so th while the atoms of ferrosum and ferricum combine with the halogens, &c., in differe proportions, or, in other words, have different degrees of equivalency, the atoms o mercurosum, and mercuricum though having different atomic weights and differen atomic heats, combine each with the same proportion of halogen, or, in other word have the same degree of equivalency; and similarly with cuprosum and cupricum (se EQUIVALENTS). A convenient mode of representing the atoms of ferricum, mercurosum &c., consists in doubling one of the letters of the respective symbols used to expre the atoms of ferrosum and mercuricum, &c., so as to indicate that the atoms of th former elements are twice as heavy as those of the latter. In a similar manner th atom of graphon might be represented by the symbol Ccc, to imply that it had thr times the atomic weight of carbon. In this way we might arrange the followi series of atoms:

Atomic heats = 3.				Atomic heats = 6.			
Carbon	.	C''''	12	Graphon	.	Gr or Ccc	36
				Aluminium	.	All'''	27·5
Ferrosum	.	Fe'	28	Ferricum	.	Ffe'''	56
Manganosum	.	Mn'	27·5	Manganicum	.	Mm'''	55
Chromosum	.	Cr'	26·25	Chromicum	.	Ccr'''	52·5
Mercuricum	.	Hg'	100	Mercurosum	.	Hhg'	200
Cupricum	.	Cu'	31·75	Cuprosum	.	Ccu'	63·5

By thus recognising the quantities represented in the second column as distinct atom we obtain nearly all the advantages, with scarcely any of the disadvantages, whic would accrue from Cannizzaro's proposal, and are enabled to account satisfactorily fo the frequent isomorphism or parallelism of the double proportions of these element with the single proportions of other elements, as illustrated below:

$KClO'$	with	$KMmO^4$	instead of	KMn^2O^4
K^2SO^4	,,	K^2MmO^4	,,	$K^2Mn^2O^4$
K^2SO^4	,,	K^2CcrO^4	,,	$K^2Cr^2O^4$
SO^3	,,	$CcrO^3$	,,	Cr^2O^3
SO^2Cl^2	,,	$CcrO^2Cl^2$	,,	$Cr^2O^2Cl^2$
Ag^2S	,,	Ccu^2S	,,	Cu^4S
Ag^3SbS^3	,,	$Pb^2CcuSbS^3$	,,	$Pb^2Cu^2SbS^3$
Pb^2S	,,	$PbCcuS$	,,	$PbCu^2S$

In addition to vapour-density and specific heat, isomorphism also furnishes valuable aid in the determination of atomic weights. As a rule, the isomorphism of aratively unknown substance, with a substance of which the formula and atomic ht are well determined, warrants us in according to the less known body a ula and atomic weight corresponding to those of the better known body. Thus, somorphism of the stannic and titanic anhydrides, of the chromate and molybdate ad, of the sulphate and selenate of sodium, assists us materially in our determin of the atomic weights of titanium, molybdenum, and selenium respectively, and e formulæ of their respective compounds. But atomic weights deduced chiefly isomorphous considerations, require to be received with very great caution, he following reasons. We sometimes find obvious chemical analogies to exist in , where from dimorphism, or some other cause, the isomorphism is very impery developed; and on the contrary, we sometimes have a marked isomorphism ing between bodies whose chemical correlations are very unsatisfactory. Thus, somorphism of potassium and sodium salts is not by any means striking. Nitrate tassium, for instance, usually crystallises in right rhombic prisms, and nitrate of um in rhomboïds. It seems, however, that each salt can crystallise in both ms, and that while the ordinary form of nitrate of sodium corresponds with the form of nitrate of potassium, the ordinary form of nitrate of potassium corres ds with the rare form of nitrate of sodium. Again, the chemical analogies of lar lead and mercury compounds are extremely well marked, but isomorphism is ifested in a very few instances only. Indeed the isomorphous relations of lead calcium are more decided than are the isomorphous relations of lead and mercury. n, tellurium is heteromorphous with its chemical analogues, selenium and sulphur, isomorphous with its chemical heterologues, arsenic and antimony. One might refer for a moment to the well-known isomorphism of certain sulphides and nides. Thus, sulphide of nickel, Ni^2S, is isomorphous with the arsenide Ni^2As, the antimonide Ni^2Sb. Marcasite, Fe^2S^2, is isomorphous with mispickel, Fe^2SAs; common pyrites, Fe^2S^2, with cobalt-blende, Co^2SAs, and smaltine, Co^2As^2. n this isomorphism a general analogy in composition between arsenic and sulphur pounds, might possibly be inferred, were it not that such an inference would dily be found incompatible with the results of chemical analysis. But if arsenic been a rare and imperfectly known element, the isomorphism of marcasite and pickel might not improbably have led to the association of its compounds with e of sulphur instead of with those of phosphorus.

oreover, 2 atoms of one element are not unfrequently isomorphous with 1 atom nother. We have already given several examples of this phenomenon when ring to the isomorphism of sulphates with chromates, M^2SO^4 and $M^2Cr^2O^4$, of hlorates with permanganates, $MClO^4$ and MMn^2O^4, and of salts of silver with of cuprosum, Ag^2S and Cu^4S; and we have shown how the anomaly could be ily explained away. Nevertheless it may be useful to point out definitely the of difficulty to which this sort of isomorphism might possibly give rise. At the ent time, the ordinary salts of zinc, iron, lead, and silver, are alike thought to be salts. Now we find that copper forms two chlorides, two oxides, two sulphides, in one set of which, the proportion of copper is twice as great as in the other. ch of these sets then comprises the protosalts? Judging from the isomorphous ions of cupric compounds with salts of iron and zinc, we should say that the ic compounds were protocompounds, and that the atomic weight of copper was . Judging, on the other hand, from the isomorphous relations of cuprous comds with salts of lead and silver, we should say that the cuprous compounds were protocompounds, and that the atomic weight of copper was 63·4.

astly, we find that isomorphism sometimes subsists between compounds of a somet similar, but not of a strictly analogous chemical constitution. Thus, hæmatite, $)'''O^3$, is isomorphous with ilmenite, $Fe''Ti''''O^3$; and zircon, $Z''''SiO^4$, with were, $(Al^2)'''Ca'SiO^4$. Again, nitrate of sodium, $NaNO^3$, calc-spar, Ca^2CO^3, and redr, Ag^3SbS^3, are isomorphous with one another; as are also nitrate of potassium, $)^3$, arragonite, Ca^2CO^3, and bournonite, $Pb^2CcuSbS^3$. Perchlorate of potassium, O^4, is isomorphous with sulphate of barium, Ba^2SO^4; and sulphate of iron, $O^4.7H^2O$, is paramorphous, if not isomorphous, with arsenate of sodium, $HAsO^4.7H^2O$. These illustrations are sufficient to show that the inferences deble from isomorphism, unless supported by chemical or by some other physical ence, must not be inconsiderately adopted as certain means for the determination omic weights and chemical formulæ.

W. O.

TRAMENTUM STONE. *Atramentenstein.* — A product of the partial ation of iron pyrites, consisting of a mixture of ferrous and ferric sulphates with ferric oxide and a variable quantity of cupric sulphate and undecomposed pyrites. used in the manufacture of ink (*atramentum*).

TRIPLEX. Many plants belonging to this genus are used for the extraction da. (Rochleder.)

ATRIPLEX VERRUCIFERA, a chenopodiaceous plant growing in the Ker steppes, leaves 12·5 per cent. of ash containing 43·3 per cent. of soluble salts, viz. 7·2 p cent. sulphate of potassium, 4·8 sulphate of sodium, and 8 carbonate of sodium, 24 chloride of sodium, and 1·9 caustic soda. (Göbel.)

ATROPIC ACID. An organic acid stated by Richter (J. pr. Chem. xi. to exist in belladonna, and to be obtained by treating the aqueous extract with alcoho ammonia, evaporating the solution with potash, and decomposing the resulti potassium-salt with sulphuric acid. It is said to resemble benzoic acid in form a volatility; but its properties, and indeed its separate existence, have not been w made out.

ATROPINE, or **DATURINE.** $C^{17}H^{23}NO^3$, or $C^{34}H^{23}NO^6$.—This alkali, d covered in 1833, almost at the same time by Geiger and Hess (Ann. Ch. Pharm. vii. 26 and by Mein (*ibid.* vi. 67), exists in all parts of the deadly nightshade (*Atropa Bel donna*); it is also contained in the seeds of the thorn-apple (*Datura stramoni* The alkaloïd has been analysed by Liebig (Ann. Ch. Pharm. vi. 66), and by Plan (*ibid.* lxxxiv. 245); the latter has also analysed many of its salts.

To extract it, the roots of the belladonna are treated with strong alcohol, and extract left some hours in contact with caustic lime, then filtered, and supersaturat with sulphuric acid, the alcohol having been previously driven off by a gentle he A concentrated solution of carbonate of potassium is then added, and the liquid filter as soon as it begins to show turbidity. The crystals of atropine, which separate af a while, are purified by repeated crystallisation from alcohol. Care must be taken to apply too strong a heat, as the atropine is easily decomposed.—Rabourdin extra the atropine by chloroform. Fresh belladonna taken at the period of flowering, heated to 80° or 90° C. to coagulate the albumin. The clarified juice, when cold, mixed with caustic potash and chloroform, in the proportion of 4 grms. potash a 30 grms. chloroform to a litre; and the whole is agitated for a minute and then to settle. After half an hour, the chloroform charged with atropine separates in form of a greenish oil, which after being washed, is distilled till all the chlorofo passes over. The residue in the retort is extracted with a little water acidulated w sulphuric acid, which dissolves the atropine, leaving a green resinous matter behi The acid solution is then treated with carbonate of potassium, and the precipita atropine crystallised from alcohol.

Atropine crystallises in colourless silky needles united in tufts; by slow evapo tion of its alcoholic solution, it is often obtained in the form of a translucent vitre mass. It is but slightly soluble in water, but dissolves readily in alcohol, less in eth It is strongly alkaline, and has a very bitter taste. It melts at 90°, and volatilises 140° C., undergoing partial decomposition. It is highly poisonous, causing verti headache, and even death; it also produces persistent dilatation of the pupil.

Chlorine acts but slowly on atropine, producing a yellowish liquid, which contain considerable quantity of hydrochlorate of atropine. Tincture of *iodine* colours it bro Hot *nitric acid* attacks it, with evolution of red fumes. *Chloric acid* dissolves it, deposits it again unaltered, by spontaneous evaporation.

Atropine dissolves readily in *acids*, but the salts are difficult to crystallise. Th are bitter, acrid, and poisonous; inodorous in the pure state. They are permanent the air at ordinary temperatures, but become coloured even at the temperature of b ing water; most of them are soluble in water and alcohol, and insoluble in pure eth *Potash*, *ammonia*, and their *carbonates*, precipitate atropine only from highly conc trated solutions of its salts; the precipitate dissolves readily in excess of the alk *Tannin* precipitates it only after addition of hydrochloric acid.

Acetate of atropine forms nacreous prisms grouped in stars: it is permanent very soluble; after being several times dissolved, it loses a little of its acid. (Geige

The *chloro-aurate*, $C^{17}H^{23}NO^3.HCl.AuCl^3$, is precipitated as a yellow powder, gradua becoming crystalline, when a strong solution of hydrochlorate of atropine is pou into a dilute solution of trichloride of gold; the liquid should be well shaken dur the mixing, to prevent the agglutination of the precipitate. The *chloromercurat* precipitated only from very concentrated solutions. The chloroplatinate is a pul rulent precipitate, which rapidly agglutinates: it is very soluble in hydrochloric a The *hydrochlorate* crystallises in tufts (Geiger); according to Planta, it is uncr tallisable. The *nitrate* forms a syrupy deliquescent mass. The *picrate* is a yel pulverulent precipitate. The *sulphate* crystallises, according to Geiger, in delic colourless, nacreous needles, grouped in stars or tufts: it is very soluble. Planta not succeed in crystallising it. The *tartrate* is a syrupy mass, which becomes m in contact with the air.

The *valerate*, prepared by dissolving atropine in an equivalent quantity of valeria

iluted with 2 pts. of ether, and cooled to 0° C., then adding a further quantity
tified ether (of 60° Cartier), equal to five times the weight of the atropine used,
aving the solution to itself in a glass cylinder at 10° C., forms colourless trans-
t rhombic crystals, which refract light strongly. According to Callmann (J. pr.
lxxvi. 69), they contain $C^{17}H^{23}NO^3 + \frac{1}{2}H^2O.C^5H^{10}O^2$. They melt at 42° C., give
e greater part of their water at 100°, and at 120° begin to evolve vapours of
anic acid. The salt prepared as above is perfectly soluble in water.

GITE. *Pyroxene.* (Gm. iii. 402; Handw. d. Chem. ii. 556.)—The name
lass of minerals distinguished:—1. By a certain form, belonging to the mono-
or oblique prismatic system, being a prism of 87° with the base inclined at an
of 74°;—and 2. By the general formula $SiM''O^3 = M''O.SiO^2$, or $3\mathit{MO}.2\mathit{SiO}^3$,*
M consists for the most part of Mg and Ca, giving the formula $\genfrac{}{}{0pt}{}{Ca}{Mg}O.SiO^2$, less
ently of Fe or Mn. Occasionally also 1Mg is replaced by 6H (polymeric iso-
ism); and in the varieties called aluminous augites, 1 at. SiO^2 by 1 at. Al^2O^3 (or
^{3} by $3\mathit{Al^2O^3}$).

cific gravity 3·23 to 3·5. Hardness = 3 to 6. Lustre vitreous, inclining to
us: in some varieties, pearly. Colour green, of various shades, verging on one
o white or greyish-white, and on the other to brown or black. Streak white to
Transparent to opaque. Fracture conchoïdal to uneven. Brittle.

nature of the metals, whether calcium, magnesium, or iron, which enter into the
sition of the mineral, produces considerable variations, not only of colour, lustre,
arency, and density, but also of crystallographical development, sometimes giving
differences in the magnitude of the angles in the primitive forms. These dif-
es of character constitute the distinctions between the several species of augite,
incipal of which are the following.

nmon Augite, (M = Ca, Mg, Fe), the silica being sometimes also replaced by
na. Black, greenish, or brownish-black crystalline masses, with cleavage parallel
faces of a monoclinic prism of 87° and 93°. Specific gravity 3·33 to 3·36. The
leveloped crystals are found in basalt and other volcanic rocks. It occurs in the
of Etna and Vesuvius, in the volcanic Eifel, in the Bohemian Mittelgebirge, in
assathal, Iceland, and in numerous other localities. In some of these augites, the
almost wholly replaced by iron and calcium. *Hudsonite* from North America,
ins chiefly iron and scarcely any magnesium, a considerable portion of the silica
mineral is also replaced by alumina (SiO^2 by Al^2O^3).

roxene.—This name is sometimes used as synonymous with augite, to denote
ntire family; but it is especially applied by some mineralogists to certain varieties
gite, having a green or dark green colour, viz. *Fassaite*, *Coccolite* (consisting of an
gation of roundish crystalline grains), *Funkite*, *Baikalite*, &c. They are dis-
shed from common augite chiefly by containing a smaller amount of iron.

opside (white augite, Mussite).—Essentially a silicate of calcium and mag-
m, $(Ca;Mg)SiO^3$, some varieties, however, containing small quantities of iron, man-
e, and even hydrogen (H^3 instead of Mg). Colour, white, greyish, or greenish-
, and light green. Occurs in very fine crystals, especially on the Mussa Alp in
nont.

lacolite.—An augite rich in magnesium, also containing hydrogen, calcium
ron being only subordinate. The water which it contains renders it softer than
nhydrous augites. *Salite* and *Pyrgom* are related in chemical composition to
olite on the one hand, and to pyroxene and diopside on the other.

allage and *Broncite* are, like malacolite, hydrated augites rich in magnesia,
aving also the silica more or less replaced by alumina. In *hypersthene*, the iron
ominates very strongly as protoxide. All these minerals, to which also the
ic talcs are related (see TALC), possess a laminated structure, arising from the
iar facility with which they cleave in a particular plane.

bestoïdal augites, are hydrated calcio-magnesian augites of fibrous structure:
of them occur as paramorphoses. This is the case with *Traversellite*, a hydrated
o-magnesian augite from Traversella in Piedmont. To this sub-species appears
to belong a nearly pure ferrous augite, analysed by Grann. (Compt. rend.
794.)

e following minerals also belong to the augite family: *Ægyrin*, probably a calcio-
m augite; *Acmite* or *Achmite* (p. 36), in which silica is replaced by alumina;
umene in which $3M''O$ are replaced by Al^2O^3; *Jeffersonite*, an augite containing
Rhodonite, a nearly pure manganese augite.

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* $\mathit{SiO}^3 = 21 + 3 \times 8$. $SiO^2 = 28 + 2 \times 16$.

The following are analyses of certain varieties of augite:

	Wackenroder.	Bonsdorff.	H. Rose.			Berzel
	a	*b*	*c*	*d*	*e*	*f*
Lime	24·74	24·76	23·57	24·94	23·47	20·0
Magnesia	18·22	18·55	16·49	18·00	11·49	4·5
Protoxide of manganese	0·18	0·32	0·42	2·00	0·61	3·0
Protoxide of iron	2·50	0·99	4·44	1·08	10·02	18·8
Silica	54·16	54·83	54·86	54·64	54·08	50·0
Alumina	0·20	0·28	0·21			
	100·00	99·73	99·99	100·66	99·67	96·3

a is diopside from Fassa; *b* from Fammare; *c*, salite from Sala; *d*, malacolite f Orrijerfor; *e* from Dalecarlia; *f* from Dagerö.

Crystals having the form, structure, and composition of augite may be obtained exposing a mixture of 1 at. lime, 1 at. magnesia, and 2 at. silica (SiO^2) to the hea a porcelain furnace, and leaving it to cool very slowly (Berthier, Ann. Ch. Phys. xxiv. 376); similar crystals are likewise found among the slags of blast-furna (Nöggerath, J. pr. Chem. xx. 501.)

The augites are not completely decomposed by any acid except hydrofluoric a Their behaviour before the blowpipe varies according to their constitution. Diop yields a colourless nearly transparent glass; ferruginous augite, a dark-coloured gl Augite dissolves readily in borax, but with difficulty in microcosmic salt, formin skeleton of silica.

AUGUSTITE. Syn. with APATITE.

AURADE. The name given by Plisson to a body which separates from oi neroli, on addition of alcohol, in white nacreous laminæ; it is probably the campho stearoptene of the oil, and appears to agree in composition with the camphor of rose It melts at 50° C., and on cooling solidifies to a waxy non-crystalline mass; in a c vessel it sublimes without decomposition. It is insoluble in water, dissolves in 10 of boiling alcohol of 44° Bm.; soluble also in ether and in oil of turpentine. I not attacked by acids. Fresh oil of neroli, which appears to be richer in this stance than the old oil, yields about 1 per cent. of it. (Handw. d. Chem. ii. 558.)

AURANTIN. Syn. of HESPERIDIN.

AURICHALCITE. (Aurum, *gold*, and χαλκός, *ore*.) A mineral occurring in tr parent, verdigris-green, needle-shaped crystals at Loktewsk on the Altai Mount It appears to contain $4CO^3Cu''.3Zn''H^2O^2$. When reduced, it yields a gold-colou alloy of copper and zinc.

AUROTELLURITE. See TELLURIUM, GRAPHIC.

AUTOMALITE. See SPINEL.

AUTUNITE. Lime-uranite. (See URANITE.)

AURUM MOSAICUM or **MUSIVUM.** The old name of disulphide of prepared in the dry way. (See TIN.)

AVENIN. A nitrogenous substance contained in oats, similar to, and most bably identical with, legumin.

AVENTURIN or **AVANTURIN.** A variety of quartz rock, which, w polished, exhibits a strong reflected light from innumerable points of its surface, ceeding partly from minute crystals of mica embedded in the mineral, partly from nute cracks and fissures. The most beautiful comes from Spain, but very fine specin have also been found at Glen Fernat in Scotland. The most usual colour is br or reddish-brown, enclosing golden-coloured spangles. The mineral is used as a g but is often replaced by the artificial aventurin-glass, which even excels it in beau

AVENTURIN GLASS, also called *gold-flux.*—A brownish-coloured g interspersed with small spangles, which give it a peculiar shining appearance. T glass was formerly used in the arts and for ornaments, and its preparation was l kept secret by the manufacturers at Murano near Venice: it is now, however, prepa in other localities. The following are analyses of this glass: *a*, by Schnedermann Wöhler; *b*, by Péligot; *c*, by Kersten.

	SiO^2	P^2O^5	Al^2O^3	Fe^2O^3	FeO	CaO	MgO	K^2O	Na^2O	Cu	Sn	P
a	65·2	1·5	—	6·5	—	8·0	4·5	2·1	3·2	3·0	trace	—
b	67·7	—	trace	—	3·5	8·9	—	5·5	7·1	3·9	2·3	1·
c	67·3	—	—	2·4	—	9·0	—	5·3	7·0	4·0	2·3	1·

an first observed that the spangled appearance of the glass is due to minute ng, opaque, crystals, having the form of octahedral segments. Hence, and from omposition of the glass, it was concluded that the crystals consist of metallic r. **Clemandot** and **Frémy** (Compt. rend. xii. 339), by melting together for urs a mixture of 300 pts. of pounded glass, 40 pts. of copper filings, and 80 pts. n filings, and cooling slowly, obtained a rather dull-looking glass containing r diffused through it in octahedral crystals.—Pettenkofer, on the other hand, main- that the spangles consist of crystals of a cuprous silicate, identical in composition, rger in size than the crystals of the compound which impart the deep-red colour ematinone-glass or *porporino* (*q. v.*), and are diffused through a mass of glass red green by protoxide of iron, the red crystals seen through the green glass cing a mixed or resultant tint of brown. Aventurin-glass may in fact be pre- with certainty by adding to 100 pts. of a not too refractory glass, 8 to 10 pts. nixture of equal parts of ferrous and cuprous oxides, and leaving the mixture to ery slowly so as to facilitate the formation of crystals. A red crystalline cuprous ound then separates, and the ferrous oxide remains in the glass, imparting a colour. Pettenkofer has also converted hæmatinone into aventurin-glass by ion of iron. (Handw. d. Chem. 2te Aufl. ii. 504.)

VENTURIN GLAZE. A glazing for porcelain invented by **Wöhler** (Ann. Pharm. lxx. 57). To prepare it, 31 pts. of kaolin from Halle, 43 quartz-sand, 14 m, and 12 porcelain fragments, the whole finely ground and levigated, are stirred ith 300 pts. of water, and to the paste thus formed are successively added the ions of 19 pts. of acid chromate of potassium, 47 acetate of lead, 100 protosul- of iron, and sufficient ammonia to precipitate the whole of the iron. After the sium and ammonium-salts have been washed out by repeated decantation, the ng is ready for use, and is laid on the burnt wares in the ordinary manner, and by the heat of the porcelain furnace. When cold, it forms a brownish ground, ining crystalline laminæ which have a golden lustre, but appear green and trans- nt under the microscope and by transmitted light; these crystals are regarded Wächter as chromic oxide or a compound of that oxide with ferric oxide.

VIGNON, GRAINS OF. (*French Berries.*) See YELLOW-BERRIES.

XE-STONE. A sub-species of jade, from which it differs in not being of so a green, and in having a somewhat slaty texture. The natives of New Zealand it into hatchets. It is found in Corsica, Switzerland, Saxony, and on the banks e River Amazon, whence it has been called Amazonian stone. Its constituents are, 50·5, magnesia 31, alumina 10, oxide of iron 5·5, water 2·75, oxide of chromium

U.

XINITE. A silicate containing boric acid, so named from the axe-like bevelling s lateral edges. It is also called *Thumite*, from one of its localities, Thum in ny. Its formula is $6M''O.2R^2O^3.8SiO^2,B^2O^3$, where $M''O$ stands for magnesia and xide of iron, and R^2O^3 for alumina, sesquioxide of iron, and sesquioxide of man- se (Gm. iii. 453). Crystalline system, the triclinic or doubly oblique prismatic. ific gravity 3·294. Harder than felspar. Colour varying from a fine violet-brown ek-green, sometimes plum-colour; some crystals are white and transparent, with ssy lustre. Before the blowpipe it exhibits the reaction of boron with acid sulphate otassium. In the unignited state, it is not attacked by hydrochloric acid, but s to it after fusion. It is found in various localities in France, Norway, Saxony, Harz, and the Alps; at Botallack, near the Land's End, Cornwall; and at Tre- nd in that neighbourhood.

ZADIRINE. A bitter principle, perhaps an alkaloid, extracted from *Melia lirachta*, an East Indian tree, by **Piddington** (Geiger's Mag. xix. 50), who s that it may be used as a substitute for quinine. According to **O'Shaughnessy** rm. Centr. 1844, p. 365), all the parts of *Azadirachta Indica* are very bitter. leaf is bitter and nauseating; the bark is peculiarly bitter, and somewhat ngent, and is used effectively in Bombay as a substitute for cinchona bark; the of the ripe fruit yields a very bitter fat oil, which possesses anthelmintic pro- ies, and is used as an embrocation.

ZELAIC ACID. An acid stated by **Laurent** (Ann. Ch. Phys. [2] lxvi. 154) produced, together with suberic and other acids, in the oxidation of oleic acid itric acid. It closely resembles suberic acid, being distinguished merely by a r melting point and greater solubility in ether. Laurent assigned to it the formula $^{16}O^4$; but it is probably nothing but impure suberic acid. (Compare Ann. Ch. rm. xxxv 103.)

ZOBENZENE. *Azobenzide, Azobenzol.* $C^{12}H^{10}N^2$. (**Mitscherlich**, Ann. Ch. . xxxii. 224; **Zinin**, J. pr. Chem. xxxvi. 96; lvii. 173; **Laurent and Gerhardt**,

Compt. chim. 1849, 417.)—A product of the reduction of nitrobenzene, or of the ox
tion of benzidine. It is obtained, together with phenylamine, by the dry distillatio
azoxybenzene; or simply by distilling a mixture of nitrobenzene and alcoholic potash
by distilling a mixture of 1 pt. nitrobenzene, 3 pts. iron, and 1 pt. acetic acid (Nob
Azobenzene passes over towards the end of the operation, as a red oil, which solid
on cooling; it is freed from aniline by hydrochloric acid, and recrystallised from alc
or ether. It forms large reddish-yellow scales, scarcely soluble in water, rea
in alcohol or ether. It melts at 65° C., boils* at 293°, and distils undecomp
(P. W. Hofmann). Vapour-density, by experiment, = 94, referred to hydro
6·50 referred to air; by calculation (2 vol.), 91 referred to hydrogen, 6·32 referre
air (P. W. Hofmann, Ann. Ch. Pharm. cxv. 364). It is soluble in nitric or sulph
acid, and is reprecipitated by water. Sulphide of ammonium and sulphurous acid
vert it into benzidine. It is not decomposed when heated to 250° C. with soda-li

When acted on by fuming nitric acid, it yields two nitro-substitution compound
Nitrazobenzene, $C^{12}H^{9}(NO^{2})N^{2}$, is formed when the reaction is not prolonged; it s
rates out in reddish-yellow crystals, which, after the acid has been decanted, are wa
with water, and dissolved in boiling alcohol (which generally leaves a residue of the
nitro compound). The solution deposits orange-yellow crystals of nitrazobenzene, w
are washed with alcohol and ether. When heated, it melts, and cools into a crysta
mass. It is less soluble in alcohol than azobenzene.—*Dinitrazobenzene*, $C^{12}H^{8}(NO^{2}$
is formed when the action of the nitric acid is prolonged for a few minutes:
crystals are deposited, which are washed with nitric acid, water, and ether, and rec
tallised from boiling alcohol. It forms small reddish needles, which may be obta
larger by crystallisation from fuming nitric acid. When heated, it melts to a blood
liquid, which crystallises on cooling. It is less soluble than nitrazobenzene in alc
or ether. Sulphide of ammonium converts it into diphenine (*q. v.*) F. T.

AZOBENZIL. $C^{21}H^{15}NO$.(?) (Zinin, Ann. Ch. Pharm. xxxiv. 190; Laur
Rev. scient. xix. 445).—Formed as a white granular precipitate, when a not *too*
centrated alcoholic solution of benzil is mixed with aqueous ammonia: after stan
in the liquid for ten hours, it is washed and recrystallised from alcohol. It fo
long, lustrous, iridescent needles, which are soluble in alcohol, alcoholic potas
ammonia, and hydrochloric acid (whence it crystallises unaltered); insoluble in wa
potash, or ammonia. F. T.

AZOBENZOIDE. $C^{42}H^{32}N^{3}$ (?) (Laurent, Ann. Ch. Phys. [2] lxvi. 190
A white amorphous powder, formed by the prolonged action of ammonia on c
bitter-almond oil. It is insoluble in alcohol and ether. When heated, it melts,
solidifies in crystalline granules; more strongly heated, it is decomposed.
F. T.

AZOBENZOIDINE. $C^{42}H^{37}N^{5}$. (?) (Laurent, Ann. Ch. Phys. [3] i. 302.)
product of the action of ammonia on crude bitter-almond oil. It forms small, shin
oblique prisms: is inodorous, nearly insoluble in alcohol, slightly soluble in ether.
is dissolved and decomposed by nitric, hydrochloric, or sulphuric acid. It solid
after fusion into a non-crystalline transparent mass. F. T.

AZOBENZOILIDE. $C^{14}H^{11}N$. (Laurent, Ann. Ch. Phys. [3] i. 304;
272.)—A product of the action of ammonia on pure bitter-almond oil. The oil
shaken up with potash and chloride of iron, distilled, and the first ⅛ which passed
was covered with an equal volume of ammonia. Crystals were gradually depos
and in three weeks the oil was half solidified. The mass, when extracted with e
left a residue of azobenzoilide.

$$2(C^{7}H^{6}O) + NH^{3} = C^{14}H^{11}N + 2H^{2}O.$$

It forms a microscopic crystalline powder, inodorous, insoluble in alcohol, very slig
soluble in ether. It is decomposed by prolonged fusion. Hot nitric acid dissolv
apparently without decomposition; hot sulphuric acid dissolves it, forming a ye
solution, in which ammonia produces a white precipitate. F. T.

AZOBENZOYL. $C^{21}H^{16}N^{2}$. (Laurent, Ann. Ch. Phys. [2] lxvi. 186.)
product of the action of ammonia on crude bitter-almond oil. When the yellow resi
mass obtained by leaving the oil for four weeks in contact with an equal volume of am
nia, is treated with boiling ether, a mixture of azobenzoyl and benzoylazotide is left un
solved: the former is dissolved out by boiling alcohol, and purified by recrystallisa
It forms a white, shining, crystalline, indorous powder, composed of irregular six-s
tables; insoluble in water, not very soluble in boiling alcohol. After fusion, it cools
transparent mass; it is decomposed by a strong heat, leaving a residue of carbon.

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* The boiling point of azobenzene is commonly stated, on Mitscherlich's authority, to be 19
doubtless from a misprint in the original memoir.

ording to Laurent (Ann. Ch. Phys. [3] i. 300), a mixture of equal volumes bitter-almond oil, ammonia, and sulphide of ammonium, solidifies after a long and on treating the product with boiling ether, a white crystalline powder ns behind, consisting of microscopic rhombic tables, which are nearly insoluble in ol, and slightly soluble in boiling ether. Laurent calls this body *hydrosulphate obenzoyl*, and assigns to it the formula $C^{21}H^{18}N^2S^4$, upon which no reliance can be l. F. T. C.

OBENZOYL, HYDRIDE OF. Syn. with Hydrobenzamide (*q.v.*)

ZOCINNAMYL, HYDRIDE OF. See Cinnamyl.

ZOCODEINE. An organic base which Anderson obtained by the action of ide of ammonium on nitrocodeine. (See Codeine.)

ZODIFUNE. Gmelin's name for Azobenzide.

ZOERYTHRIN. See Orcein.

ZOLEIC ACID. Syn. with Œnanthylic Acid.

ZOLITHOFELLIC ACID. See Lithofellic Acid.

ZOLITMIN. See Litmus.

ZOMARIC ACID. See Pimaric Acid.

ZOPHENYLAMINE of Zinin. A product of the decomposition of nitro ylamine by sulphide of ammonium. (See Phenylamine.)

ZOPHENYLAMINE of Gottlieb, more correctly *Nitrazophenylamine*. A uct of the decomposition of dinitrophenylamine by sulphide of ammonium. (See ylamine.)

ZORITE. A mineral occurring in the trachytic rock of the Azore Islands, in greenish or yellowish white pyramids. According to Hayes, it consists for the part of tantalate of calcium.

ZOSULPHIDE OF BENZENE. Syn. with Hydride of Sulphazo-benzoyl hiobenzaldin. (See Benzoyl-hydride, decompositions by sulphide of ammonium.)

ZOTE. (ἀ privative and ζωή life.)—Lavoisier's name for nitrogen.

ZOTAN. A name, not much used, for chloride of nitrogen.

ZOTIDES. Syn. of Nitrides.

ZOXYBENZENE. *Azoxybenzide*, *Azoxybenzol*. $C^{12}H^{10}N^2O$. (Zinin, J. pr. n. xxxvi. 96; lvii. 173; further, Ann. Ch. Pharm. cxiv. 217; Laurent and hardt, Compt. chim. 1849, 417.)—When to a solution of 1 pt. nitrobenzene in ls. absolute alcohol, 1 pt. powdered potash is added, the whole becomes brown, and ated to boiling. The mixture is shaken up and kept boiling for some minutes: on ng it sometimes deposits brown crystals. The mother-liquor is decanted, and lled till it forms two layers. The upper is a brown oily liquid, which, after deation and washing with water, solidifies into a mass of brown needles; the lower ains aqueous potash, carbonate of potassium, and a brown potassic salt, almost inle in alcohol. The crystals are dried with filter-paper, and recrystallised from hol or ether: they are easily decolorised by passing chlorine through their alcoholic ion. 2 pts. nitrobenzene yield 1½ pt. azoxybenzene.

hus obtained, azoxybenzene forms yellow, shining, four-sided needles, often an inch as hard as sugar, without smell or taste, insoluble in water, hydrochloric, or dilute huric acid, potash, or ammonia, readily soluble in alcohol, still more so in ether. It s at 36° C., and solidifies on cooling to a crystalline mass: it is decomposed by dry llation, yielding aniline and azobenzene, and leaving a residue of carbon. It is attacked by chlorine: bromine attacks it, forming a yellow componnd, very slightly le in alcohol. Strong sulphuric acid dissolves it, forming apparently a copulated . Sulphide of ammonium and sulphurous acid convert it into azobenzene.

itrazoxybenzene, $C^{12}H^9(NO^2)N^2O$.—Azoxybenzene is not attacked by dilute c acid, but when gently heated with nitric acid of specific gravity 1·45, it dissolves, great evolution of heat, and the liquid, if carefully cooled, solidifies after a while, to ick pulp, consisting of two isomeric nitro-compounds, nitrazoxybenzene, and itrazoxybenzene, which may be separated by their different solubility in hol. If the pulp just mentioned be thrown on a filter, washed with water, treated e or four times with a quantity of boiling alcohol not sufficient to dissolve the le (not more than 4 pts. alcohol to 1 pt. azoxybenzene), and the decanted liquors to cool, crystals of nitrazoxybenzene are first deposited; and after a while, shining lles make their appearance in the midst of them. If the liquid be then filtered, part of the alcohol distilled off, isonitrazozybenzene separates on cooling, in the of an oil, which quickly solidifies in a crystalline mass; it may be purified by or three crystallisations from small quantities of very strong alcohol.

Nitrazoxybenzene is a yellowish crystalline body, slightly soluble in boiling alc
or ether. It is promptly attacked by boiling alcoholic potash, and coloured br
on adding water, a yellowish-red powder is precipitated, which may be crystall
from boiling oil of turpentine. This compound appears to contain $C^{12}H^{9}N^{3}O$ (L
rent and Gerhardt). If the action of alcoholic potash be prolonged, the mix
becomes blue; the colour is destroyed by water. An alcoholic solution of sulphyd
of ammonium converts nitrazoxybenzene, with separation of 3 at. sulphur, into a c
tallisable base, which dissolves readily in alcohol and in benzene, and forms salts
acids.

Isonitrazoxybenzene forms crystals very much like those of nitrazoxybenzene,
easily soluble in alcohol. It dissolves also in a large quantity of ether, and in benz
and often crystallises from these liquids in fine rhomboïdal prisms. It melts at 49
but does not volatilise without decomposition. When 1 pt. of this substance is tre
with a solution of 1 pt. of potash in 8 pts. of alcohol, it melts and dissolves
ebullition, giving off the odour which is evolved on treating nitrobenzene with alco
potash. On boiling the liquid, a resinous mass separates, which yields by distilla
an orange-coloured product, which crystallises from alcohol, and resembles ni
phenylamine. At the same time, an oily body is formed, not possessing basic proper
and charcoal remains behind.

Isonitrazoxybenzene treated with alcoholic sulphydrate of ammonium, yields a b
having the composition $C^{12}H^{9}N^{3}O$:

$$C^{12}H^{9}(NO^{2})N^{2}O + 2H^{2}S = C^{12}H^{9}N^{3}O + 2H^{2}O + S^{2}.$$

This body is insoluble in water, very soluble in alcohol, ether, benzene, and rock
soluble also in acids; but does not form definite salts. It melts at 85° C. to a ye
liquid, which solidifies on cooling, provided the temperatnre has not been raised
high. If a strong heat be applied, a brown liquid distils over, soluble in alco
though less so than the original substance. F. T.

AZOXYDIFUNE. Gmelin's name for AZOXYBENZENE.

AZULMIC ACID. A brown substance produced by the spontaneous decon
sition of cyanogen and hydrocyanic acid.—An aqueous or a dilute alcoholic solutio
cyanogen or aqueous hydrocyanic acid, when left to itself for some time, especially
addition of ammonia or potash, acquires a brown colour and gradually deposits br
flakes, consisting of azulmic acid. The solution contains azulmate of potassiun
ammonium, from which the acid may be precipitated by the stronger acids.
same product is obtained by passing cyanogen gas into aqueous ammonia or alcoh
potash.—Respecting the composition of this substance, statements vary greatly;
cording to Pelouze and Richardson (Ann. Ch. Pharm. xxvi. 63), it is $C^{4}H^{4}N$
that is to say, 4 at. cyanogen + $2H^{2}O$: but it is doubtful whether any of the anal
have been made upon a pure definite compound. The acid yields by dry distilla
hydrocyanic acid, ammonia, and water, and leaves a residue of charcoal contai
nitrogen. (For a full account of all the modes of preparation, properties, and react
of azulmic acid, see Gmelin's Handbook, xi. 375.)

AZURE-BLUE. See SMALT.

AZURE-STONE } See LASULITE.
AZURITE }

B

BABINGTONITE. A mineral consisting principally of silicate of iron and
cium, found near Arendal in Norway, in the Shetland Isles, at Gouverneur in St. L
rence County, New York, and at Athol in Massachusetts. It forms short, nearly r
angled rhomboïdal prisms, of the triclinic system, with truncated edges and obtu
bevelled summits. Fracture imperfectly conchoïdal. Colour dark greenish-bl
with vitreous lustre. Opaque in the mass, translucent in thin splinters. Hard
5·5 to 6·0. Specific gravity 3·4 to 3·5. Brittle, producing a greenish-grey str
Melts easily with intumescence before the blowpipe, forming a brownish-black shi
globule, attracted by the magnet. It is slowly decomposed by boiling hydrochl
acid. The mineral has been analysed by Arppe (Berz. Jahresb. xxii. 20),
by R. D. Thomson (Phil. Mag. [3] xxvii. 123), but its formula has not yet b
determined:

SiO^{2}	MgO	CaO	FeO	MnO	$Al^{2}O^{3}$	Loss by ignition.		
54·4	2·2	19·6	21·3	1·8	0·3	0·9	=	100·5 (Arppe)
47·5	2·2	14·7	16·8	10·2	6·5	1·2	=	99·1 (Thomson

BABLAH or **NEB-NEB.** The commercial names for the fruits of seve

of acacia. The principal varieties are East Indian bablah, from the *Acacia*
lah (*Roxburgh*), and Senegal and Egyptian bablah, from *Acacia nilotica*
). The pericarp of these fruits contains a dark brown astringent juice. The
s extract contains, according to Chevreul (*Leçons de Chimie appliquée à la*
re, ii. 211), gallic and tannic acids, a red colouring matter, and a nitrogenous
nce, besides other substances not yet examined. East Indian bablah yields to
water 49 per cent. of soluble matter; Senegal bablah 57 per cent.; neverthe-
cording to Guibourt, the East Indian variety is richer in tannic and gallic acid,
erefore more valuable. Bablah is used in calico-printing in combination with
a and iron mordants, to produce various shades of fawn-colour. The tint pro-
by the seeds is different from that obtained with the husks; the seeds are said
tain a red colouring matter, and to be used in Egypt and India for dyeing
o. (Handw. d. Chem. 2te Aufl. ii. 603.)

BUL-GUM or **GOND-BABUL**, an inferior sort of gum arabic, from the
tree, *Acacia Arabica* (*Willd.*) growing in Bengal.

BYLONIAN QUARTZ. This name is given to peculiar groups of quartz-
s, composed of thin crystalline plates, disposed one above the other like terraces.
ound at Beerlston in Devonshire.

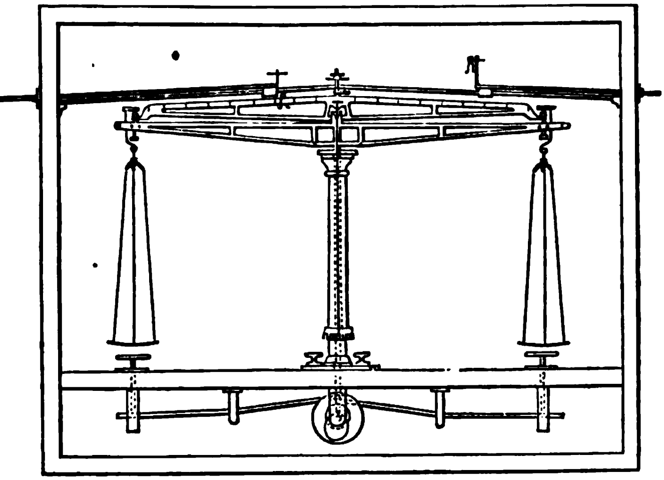
GRATIONITE. See Orthite.

ERIN or **BAIERITE.** A variety of niobite found at Bodenmais in
a and at Limoges in France.

KALITE. A green modification of diopside.

LANCE. Chemistry being concerned with the relative masses or quantities
elements which compose all known substances, and the weight or force of
ation of a body being the only practicable measure of its mass or quantity
tter, the balance, which shows the equality of two weights, and may hence
ine the ratio of all commensurable weights, is the chemist's most important
nent.

Fig. 78.

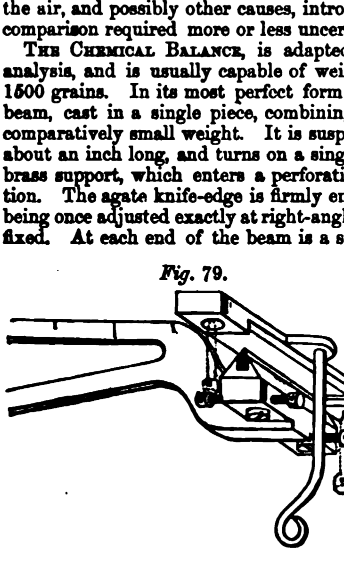


eoretically speaking, the balance consists of a lever or inflexible straight line
g with perfect freedom on its central point. A weight is applied to each extreme
and the force of gravity acting perpendicularly downwards, if either of these
ts be in the least degree greater than the other, it will prevail and cause the lever
olve in its own direction. The equilibrium of the lever or balance affords the
d criterion of perfect equality of weight; and an arbitrary weight being assumed
standard, we can arrive, theoretically speaking, at any of its multiples or sub-
ples by successive duplication and bisection combined with addition and sub-
on, and a perfect measure of all weights from the greatest to the least may thus
tained. The results of course are not absolute weights, as we say in common
n, but *ratios* of weights to each other, or to the standard unit-weight.

ctically, however, the balance consists of a metal beam with two almost equal and similar arms, suspended near its centre of gravity on a pivot, the weights t compared being also suspended from two pivots at nearly equal distances from centre pivot. In the balance thus constructed, we have by no means the simple perfect comparison of two weights supposed in theory; the weight of the beam, friction of the pivots, their unequal distances from the middle one, the resistanc the air, and possibly other causes, introduce small extraneous forces, which render comparison required more or less uncertain and erroneous.

THE CHEMICAL BALANCE, is adapted for the ordinary operations of quantit analysis, and is usually capable of weighing any quantity less than 100 gramme 1500 grains. In its most perfect form (see *fig.* 78) it consists of a perforated b beam, cast in a single piece, combining great strength and perfect inflexibility comparatively small weight. It is suspended at the centre on a knife-edge of a about an inch long, and turns on a single polished plane of agate fixed on a proje brass support, which enters a perforation of the beam, and does not impede its tion. The agate knife-edge is firmly embedded in a wedge-shaped piece of brass, being once adjusted exactly at right-angles to the plane of the beam, is then permane fixed. At each end of the beam is a smaller agate prism (see *fig.* 79), with the uppermost, fixed in a brass setting, w is capable of a little lateral movement slides upon a brass plane, in such a ner that the two extreme edges and centre edge are all appreciably in plane, as may be seen by looking a them. The extreme edges may be m to or from the centre edge by little justing screws, and fixed in the de position with the assistance of two cl ing screws.

Fig. 79.



Upon these extreme edges (*i. e.* k edges) are balanced two agate planes, which, by the bent wire and a series of l and light wires, the pans are suspend

Except, however, when a weighing is actually being made, the agate planes edges are never in contact, but the beam and pan suspensions are borne by a fram movement, having in the centre two Y's (*fig.* 78) which catch projecting pins clo the centre edge, and lift the beam about $\frac{1}{100}$ of an inch off the plane, while steel p (shown in dotted outline in *fig.* 79.) entering hollows in the lower surface of the suspensions, likewise raise these planes off the edges, and retain them in the e positions proper for a new experiment. The movement of the brass frame is gove by a rod descending through the pillar of the balance and resting on a simple eccen by the turning of which it is gradually raised or lowered. In the best balances t second eccentric, by means of two bent levers, raises supports beneath the pans o balance, and either holds these safely while weights are being placed in them checks their oscillations preparatory to the release of the beam. The two eccentric so adjusted that on turning the handle, the pan supports are first rapidly drop the beam is then very gently lowered on to the centre plane; and lastly the suspensions are in the most delicate manner left free upon the extreme edges beam being perfectly horizontal and undisturbed, so as not to show the slightest pre derance one way or another. Much of the excellence of a balance, as it is empl in chemistry, depends upon these several movements being smoothly performed, the parts being released without the least stickiness; otherwise the beam is th into oscillation, and the true approach to equilibrium cannot be readily observed.

Most of the weight of the beam and frame is usually borne by a spiral spring i interior of the column. An index moving over an ivory scale one inch long, div into twenty parts, indicates the movement of the beam. The index should, of co point exactly to the centre division, both before the beam is raised and when it is and unloaded. The balance is enclosed in a glass case, with convenient windows shown in the figure; but when a very bulky object has to be weighed, the fi screws at the base of the column (*fig.* 78) are to be loosened: the column and b may then be turned through about 60°, so that the scales extend without the Two spirit-levels, or a circular level, and levelling screws, are attached by which whole instrument must be adjusted to horizontality. Above the centre of the b is a small weight, which we may call the *gravity-bob*, and which, being screwe or down, regulates the stability of the balance, while a small *vane* being turned t right or the left adjusts the beam to equilibrium. In the figure too will be see arrangement of rods, by which a small rider weight may be placed upon any pa the beam, the balance case remaining closed.

he balance above described is by Oertling, of Bishopsgate Street, London, who like- constructs the chemical balance in seven different varieties more or less elaborate,

Fig. 80.

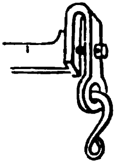


Fig. 81.

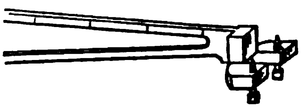
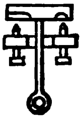


Fig. 82.



largest of these, with a 16-inch beam, able to bear two pounds in each pan, and turn with $\frac{1}{100}$ grain is a remarkably fine instrument. The German balances made Oertling of Berlin, Staudinger of Giessen, Steinheil of Munich, and others, are emely delicate and well made instruments. Deleuil of Paris enjoys also a just brity for his chemical balances. M. Stas, in his late researches upon the atomic ghts, employed a balance Gambey, which turned to a milligramme when laden a kilogramme; also one Sacré of Brussels, carry- two or three kilogrammes turning with 0·3 milli- mme. *Fig.* 83 shows the ninal suspension of a de- te balance by Fortin of is, capable of indicating part in a million, while 84 is from a German ba- ce.

Fig. 83.

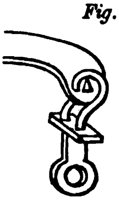
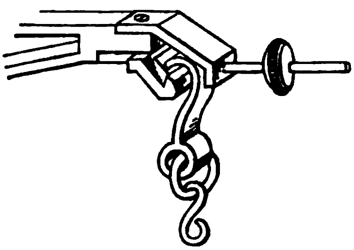


Fig. 84.



HE ASSAY BALANCE is specially adapted for weighing small objects with great uracy and rapidly. The French assay balances consist of a very light steel beam unted in the manner of a pair of scales with hook pan suspensions, yet their perfor- nce is good.

Oertling constructs the assay balance in five forms, of which the most commonly ployed has an 8-inch plain brass beam with a centre steel knife-edge and hook pan pensions, adjustable by a small screw, as shown in *fig.* 80. It is not adapted to r more than two grammes in each pan, and will perhaps indicate the $\frac{1}{20}$ part of a ligramme.

nother kind has an 8-inch perforated beam, with three agate edges and planes, in fact all the elaborate movements and adjustments of the chemical balance ve described, on a small scale. It will bear 10 or 15 grammes in each pan, and yet icate surely and *rapidly* about $\frac{1}{20}$ of a milligramme.

astly, we may mention the 10-inch assay balance, with a very light perforated m. A figure and a short description of this balance will be found under the article LD ASSAY, but the terminal suspensions are shown here in *figs.* 81 and 82, and are ned of two small screws, bearing sharp points of ruby, one working into a little low, the other into a little channel in a steel cross-piece, from which the pan is pended.

n contrast to the last balance it may be mentioned that Oertling constructs balances the principles of the chemical balance with a beam 4 feet long, able to bear 0 ounces in each pan, and yet turn with half a grain, or the one-millionth part of the l. They are chiefly employed in the several English and American mints for ghing bullion, but might be useful in some scientific investigations. See Jury orts on the Great Exhibition of 1851 (p. 258).

t is of little use to describe forms of the balance which are now antiquated. Those by binson, by Ramsden, and his successor, Berge, and by Barrow, had beams composed wo hollow brass cones joined at the base with many elaborate adjustments. A ance made by Ramsden for the Royal Society is said to have indicated one part in n millions. In the Göttingen Transactions, is described a balance constructed by ss and Weber, the beam and scales of which were poised on watch springs, a hod contrived by Gauss. Beams suspended by ribbons, threads, or turning on e spheres of steel have been tried by Steinheil; but in no instrument have attempts nvent new forms been more futile.

The Adjustment of the Beam to the due degree of sensibility and accur has to be entirely performed by repeated trial-weighings, and requires the great skill.

Firstly, if the three edges of suspension are not already in one plane, but admit adjustment, as is sometimes the case, proceed as follows:—Without weights the pans poise the beam, and then raise or lower the *bob* until the vibrations are r dered very slow; now put weights into the pans equal to about half the greatest lo the balance is to carry, so that the beam may be poised again; if it now vibra slowly as before, it proves the adjustment to be perfect; but in case it either ov sets or vibrates too quickly, restore it to slow motion by the adjusting weight *gravity-bob*, as we may call it, noting the number of turns of the screw and parts o turn which were required to produce slow motion; now turn the screw the contrary w through double the noted quantity, and then produce the required slow motion by proper adjustment at the end of the beam. Repeat the operation till the adjustm is perfect.

Secondly, to adjust the edges of suspension to equal distances; poise the beam w weights as in the last case, and then change the pans and suspensions from one side the other. If equilibrium still holds, the adjustment is perfect; if not, take as m hair or wire as when put into the apparently lighter scale, will restore the balan take away half of it, and poise the beam by the proper adjustment at the left e which completes the process. Instead of placing any weights in the pans, all poising may be conveniently done by a rider-weight on the beam, and in the l operation it is to be removed half way towards the centre of the beam. The adju ment of the edges to perfect parallelism is of course indispensable; we only presu that it is done by placing narrow planes or hooks on different parts of the edges moving these until the apparent weight is the same on whatever part the wei bears.

A good balance in perfect adjustment should bear most of the following tes Without weights, of course, it should remain with the index at zero, or make eq slow excursions on either side. The pans being removed, the beam alone should be equilibrium, and oscillate probably much more quickly. If there be nothing in the c struction of the balance to hinder it, the beam should be turned round from left to ri and should act as before; this test is a severe one, generally disclosing as it d some defect in the work of the middle knife-edge and the planes on which it re If the pans and suspensions have been separately adjusted to equality, which advantageous, although not quite necessary, equilibrium should hold when the p and suspensions are variously changed in both positions of the beam. Lastly, pans being fully and equally loaded, the weights should be changed from pan to p and equilibrium yet hold, proving the lengths of the arms to be fully equal.

A good balance, too, may be known by its giving the weight of an object, the same nearly so, when weighed several times successively. There are few balances that do this with certainty to the last minute fractions which they are capable of dicating.

Weights.—The results required by the chemist in analyses being merely comparat or proportional, the choice of a unit weight is a matter of indifference, provi that it be not varied during the progress of an experiment. But it is most c venient to adopt weights connected with some national standard, so that absol weighings may if necessary be recorded. Grain weights are still sometimes used English chemists, but most men of science of all nations appear by a kind of t agreement to have adopted the French standard weight, the gramme, with its unif series of decimal multiples and submultiples; and we therefore strongly recomm its exclusive employment by every scientific chemist.

A complete set of weights extends from the smallest that the balance will indic up to the greatest that it will bear, and the series usually supplied with a balanc as follows:—

·001 gramme	·01 gramme	·1 gramme	1·0 gramme	10·0 grammes
·001 „	·01 „	·1 „	1·0 „	10·0 „
·001 „	·02 „	·2 „	1·0 „	20·0 „
·002 „	·05 „	·5 „	2·0 „	50·0 „
·005 „			5·0 „	

the whole making up just 101 grammes. These are arranged most conveniently in little wooden stands, which may either be introduced into the balance case or enclo together with the forceps in a separate box. A glass cover also lies over the sn weights. The weights from 1 gramme upwards are best made of brass *gilt*; be 1 gramme, of platinum in the form of flat squares, with a corner bent up for hold in the forceps, the weight being stamped on each piece. The milligramme weig sometimes made of palladium or aluminium ; but the latter metal is rather too soft the purpose, and is apt to wear away.

n admirable improvement in the modern balance consists in its partial employment the principle of the steel-yard, as far as regards the estimation of the last minute tions. A small *rider*, or hanging weight of thin gold (or brass) wire, is placed upon upper edge of the beam either by the forceps, or more conveniently without opening case, by a brass sliding rod and a little arm (see *fig.* 78), on either side of the beam. w the weight which this rider exerts towards turning the beam is such a fraction of whole weight in the pan, as its distance from the centre of the beam is of the distance he pan-suspension from the centre. The rider commonly weighs ·01 gramme, and h arm of the beam is graduated into twenty parts; but the fifth part of these isions may easily be guessed, so that the fractional weight may really be read off to $\frac{1}{100}$ part of the rider weight, or ·0001 gramme. This simple contrivance, compared h the use of minute weights in the pans, presents the following advantages.

. Saving of much time and trouble. 2. Greater accuracy, small weights being le to collect dirt, or to be rubbed or injured. 3. Minute estimation of weights to required degree. 4. Diminished chance of error in reading off the weight. With nerous small weights errors are *certain* frequently to occur.

he series of grain weights 1, 2, 3, 4, 10, 20, 30, 40, &c. is not uncommonly em- yed, and is quite as convenient as the series 1, 1, 2, 5, 10, &c. As a curious fact, it y be mentioned, that the series of powers of 3, viz. 1, 3, 9, 27, 81, affords the greatest nber of combinations to a given number of weights. Thus twelve such weights give *addition or subtraction*, any integral number from 1 to 265,720, while 21 weights of series, 1, 1, 2, 5, do not reach 200,000.

Veights when used in a laboratory must almost always become too light by wear, c re commonly too heavy by corrosion of the brass. Were the error always propor- nal to the size of the weight, all error would be eliminated in any comparativ ult. But this is not usually the case, since the mass increases as the cube, whil surface increases as the square of the diameter. Hence the small weights will be re erroneous in proportion than the large. Weights should never be rubbed, and if sty, should be wiped with a silk handkerchief or a camel's-hair brush. Small *platinum* ights may be cleaned if necessary, by momentary exposure to the flame of a spirit- np. One set of weights should, if possible, be carefully preserved beyond the in- ence of fumes, and should not be touched but by ivory-pointed forceps. The weights nmonly used should occasionally be tested against these, to see whether their errors disproportionate; or weights may less satisfactorily be tested against each other. experienced weigher will never trust even the best balance maker as to the ac- racy of his weights, but will always test them against each other in various ways, on t receiving them. Many conclusions, observes Faraday, tending to subvert most portant chemical truths, might be quoted as having arisen solely from errors in ights and balances.

In assaying (see GOLD ASSAY), a special unit and set of weights is adopted to suit weighings required; the same might be advantageously done in any large set of alyses or experiments.

Much time will on the whole be saved in weighing, if the weights be taken me- odically in their proper order, 10, 5, 2, 1, 1, except, of course, the slow motion of balance indicate that only a small weight more should be added. For if an unknown ight exceed 10 but fall short of 20, it is an even chance that it be above or below 15, that if the weights 2, 1, 1, be used after the 10, it is *as likely as not* that the igher will lose his trouble, and have to resort to the weight 5. In this respect the ies of weights (avoirdupois) 16, 8, 4, 2, 1, ½, ¼, &c. is obviously the most advantageous.

When equilibrium is nearly attained, the expert weigher will notice the rapidity th which the index of the beam traverses the arc, or the extent of the oscillation if be less than the whole arc, and comparing this with the load in the pans, and with previous experience of the same balance, will closely estimate the alteration of ight required, and thus save half the time and trouble which the adjustment would herwise have occupied. It will afterwards be shown that the oscillations of a good lance may give sure determinations of the most minute fractional weights.

We cannot too strongly impress upon the reader the danger of mistakes in reading the weights in the pan of a balance. The danger is greater with small than with ge weights, and this alone would be sufficient reason for the use of a rider weight. In y case, the weights in the pan should be read, then taken out and arranged in order, d again read; lastly restored to the pan, and fresh trial made. Or the reading of the eights may be compared with the vacancies in the box of weights. When the vibra- ns of the balance have to be read, the divisions of the scale should be numbered om left to right continuously. For if the zero be in the centre, the signs + and — ust be used, and mistakes are sure to occur. Under the article GOLD ASSAY will be

found an instance in which vibrations are used with great convenience in estimat
the last fractions of weights.

The casual sources of mistake are too many to mention. Not unfrequently a ri
may remain unnoticed on some part of the beam, and vitiate several weighings. Wl
a bulky or flexible object is being weighed, some part is very likely to come in cont
with the balance case. We have even known a scrupulously exact gold-assayer
into serious mistakes by a small fly, which settled on his balance, unobserved at
time.

An object heated many degrees above the temperature of the air, cannot be accurat
weighed; for it is surrounded by ascending currents of air, which cause its appar
weight to vary every moment, and it is very likely to heat and expand unequally
arms of the beam above. Special modes of weighing hygroscopic substances, liqu
powders, gases, &c., must be adopted according to the nature of the case; the chen
must generally depend for these on his own ingenuity, but will find many valua
directions in Faraday's Chemical Manipulation, section II., also in Greville Willian
Chemical Manipulation.

If we have to compare the weights of any two objects, A and B, which are held
accompanied by other objects, X and Y, the weights of the latter may be perfe
eliminated if each of A and B be weighed as often in X as in Y, and the mean re
taken.

We will make the following suggestions for the care of a balance.

1. It should never be moved, if possible, from its appointed place; for this wo
not only disturb its adjustment to horizontality, but the swinging and shaking of
pans and beam would be likely to injure or slightly alter the condition of the balar
The operator too will never weigh so well as in a place, and with a light to wh
he is accustomed.

2. The balance should not be cleaned or altered often or hastily. A good clean
once every three months, for instance, is enough, if the balance case be kept
closed. An hour or sometimes two or three, may well be spent in the operation
cleaning. All the loose parts should be carefully taken out and dusted; the mo
ments cleaned and fresh oiled; the suspensions polished with a piece of soft leath
Then all the parts are to be put together again, and brought to elaborate adjustme
which with careful usage will be maintained for some months.

3. The chemist should be perfectly acquainted with the capacity, the gene
character, and also the particular condition, at any moment, of each of his balances

4. Before every weighing, or set of weighings, he should try whether the unloa
balance is in perfect equilibrium; if not, he may brush the pans or beam with
camel's hair brush, to remove dust, or if he dust the preponderating side only, it
often restore equilibrium. He should not touch the little regulating vane, or alter
part of the balance, without being satisfied that some special cause for it has aris
The one great essential of accuracy is perfect uniformity in everything but the th
to be measured, and no one can have faith in a measuring instrument which is alw
changing.

5. It is almost needless to say that a balance, especially one with steel knife-edg
must be kept beyond reach of all acid fumes or damp. A small vessel of quick li
or chloride of calcium should be in the balance case, and this should be kept constan
closed.

All weighing out of reagents, where a grain more or less is not material, sho
be made with common apothecaries' scales on the laboratory table.

A balance should be placed in a good light, falling if possible over the right shoul
of the operator. But it may also with advantage be placed before a window, provi
that a purple silk shade be used. The purple light thus thrown behind the balanc
subdued, agreeable, and complementary to the yellow of the brass. As a general r
the object to be weighed should always be placed in the left hand pan, which we m
hence call the *object-pan*. The other, or *weight-pan*, will thus be conveniently oppo
the right hand. In assaying, this arrangement is reversed.

The number of balances required in a chemical laboratory may vary from one
twenty, or more, according to the size and purposes of the laboratory. For the co
mon operations of quantitative analysis, the chemical balance first described
alone necessary. A larger balance will, however, be almost indispensable in wat
analyses, and in many physico-chemical investigations, and will always be a
vantageous by allowing the use of large evaporating dishes and vessels, or
weighing of a series of drying tubes, or other apparatus as a whole. But a laborat
is not complete without an assay balance, which will perform all light weighings w
an accuracy and expedition impossible in a large balance.

When the employment for balances is very extensive, it will be best accommodat
not so much by increasing the number of balances as by classifying them, assigning

its proper work, and strictly adhering to rules once laid down. Where there are alances of the same kind, it is obviously best to retain one for the more refined oses, and make the other perform all common work, and two balances thus used serve better than half a dozen indiscriminately worked and spoiled.

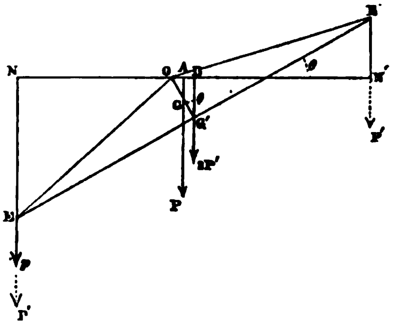
Mechanical Theory of the Balance.

operly to understand the action of a balance, it must be considered both statically dynamically, that is to say, both when the beam is at rest and while it is in on; for the oscillations of a good balance are almost as valuable an indication as osition at rest.

rst, however, to show the conditions of equilibrium, let O (*fig.* 85) be the central of suspension of a balance, and EE′, the extreme axes of suspension not neces- in the same straight line with O. Suppose equal weights, each = *P*′, to act at d E′, including of course the weight of the burthen, pans, other objects suspended at the me axes. Then the whole ht 2*P*′ may be conceived as g at G′, the middle point of ine EE′. Assuming the axis O properly placed at equal dis- s from E and E′, the line OG′ be perpendicular to EE′, and weight of the beam, say *P*, will at its centre of gravity, which should be, some point G, on line or its prolongation.

stly, let some small additional ht *p* act at E. The beam can ow remain horizontal, but may rest in equilibrium in some ion inclined at an angle, say θ, to the horizontal line NN′. Drawing E N, E′ N′, G′ B, perpendicular to NN′, we must have, according to the principle of the , the sum of the moments of the forces on one side equal to that on the , or

Fig. 85.



$$2P'.\mathrm{OB} + P.\mathrm{OA} = p.\mathrm{ON} = p(\mathrm{BN}-\mathrm{BO})$$

ubstituting in terms of θ, we have

$$2P'.\mathrm{OG}'.\sin\theta + P.\mathrm{OG}\sin\theta = p.\mathrm{G'E}.\cos\theta - p.\mathrm{OG}'.\sin\theta$$

$$\tan\theta = \frac{\sin\theta}{\cos\theta} = \frac{p.\mathrm{G'E}}{(2P'+p)\mathrm{OG}'+P.\mathrm{OG}}$$

for small values, *tan θ* varies very nearly as the angle of deviation θ, which angle be regarded as the true measure of the sensibility of the balance, and *p* being inconsiderable compared with 2*P*′ and *P*, we may say that *the sensibility is in- ed by increasing the length of the beam, diminishing the weights of the beam and or diminishing the distances of G and G′ from the axis O*, and also that *the sensi- varies very nearly in the direct or inverse ratio of these changes.*

ain, the force tending to restore the beam to the horizontal position when dis- d is *sin θ* (2*P*′ . OG′ + *P* . OG). This is the measure of the *stability* of a balance, tain degree of which is required to render a balance useful. Now with given hts *P* and *P*′, and for any given deviation θ, the force of stability will entirely nd upon the positions of G and G′, and the following are the cases which arise.

The extreme points of suspension EE′ may be so placed that G′ falls above O. stability is *sin θ* (*P* . OG − 2*P*′ . OG′), which for a certain value of *P*′ will be *nothing*, hat the whole system will be suspended at the centre of gravity, and the beam disturbed will have no tendency to return, but will rest in *neutral equilibrium*, ferently in any position.

r a greater value of *P*′, the force will be *negative*, and the equilibrium unstable, is to say, the beam when loaded beyond a certain degree will *overset*, and per- ently sink down on one side without a tendency to return, even when the weights he two sides are not unequal. A balance of such construction then, could only be for weights of a certain smallness, and its *sensibility* would increase and its lity decrease with its load.

If G fall above O and G′ below, the stability is *sin θ* (2*P*′ . OG − *P*′ . OG), which be *nothing* for a certain value of *P*′, and negative for smaller values. The balance then would be *stable* only when P', the load in the pans, is not less than a cer magnitude.

3. If G coincide with O (OG = 0) and G′ fall above O, the balance is always stable and useless.

4. If G coincide with O and G′ fall below O, the stability is $2P' . OG' . \sin\theta$, wi depends entirely upon the weight placed in the pans.

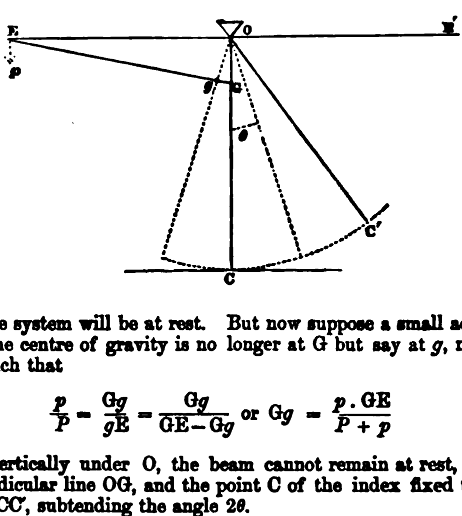
5. Now let G′ coincide with O, (OG′ = 0) the three points EOE′ being in a stra line, but let G fall below O. The stability is $\sin\theta . P . OG$, which for a given value of is constant. Also $\tan\theta = \frac{p . OE}{P . OG}$ which depends only on p. In a balance of construction, all weights may be weighed indifferently and with equal accuracy, any required degree of sensibility may be obtained by duly regulating the le of OG.

6. Let G and G′ coincide; then $\sin\theta . OG(2P' + P)$ is the measure of stability, is proportional to the weight to be moved. Also $\tan\theta = \frac{p . GE}{(2P' + P + p)OG}$ v inversely as the total weight moved.

In any case of stable equilibrium, it will be easy to determine the position of centre of gravity (say g) of the *whole system* from the formula $Og = \frac{p . OE}{\tan\theta(2P' + P}$ by observing the deviation for several values of p, and for a given load P' in the A different value will be found for Og for each different value of P′, unless the ba be constructed in the sixth mode described above. In a sensitive balance Og, probably not exceed $\frac{1}{10000}$ part of an inch.

We may now consider the balance in the character of a compound pendulum, se ing for this purpose the fifth mode of construction above described. Thus if G centre of gravity of the beam (*fig.* 86), be vertically under O, and the weights in

Fig. 86.



pans be equal, the system will be at rest. But now suppose a small additional we p added at E : the centre of gravity is no longer at G but say at g, nearer to E b distance (Gg), such that

$$\frac{p}{P} = \frac{Gg}{gE} = \frac{Gg}{GE - Gg} \text{ or } Gg = \frac{p . GE}{P + p}$$

Since g is not vertically under O, the beam cannot remain at rest, but will vib about the perpendicular line OG, and the point C of the index fixed to the beam describe the arc CC′, subtending the angle 2θ.

The velocity of the beam is greatest, of course, when g is vertically under O, being proportional, as proved in the theory of dynamics, to the angle θ, is nearly proportional to p. Hence when the deviation is small, *the greatest velocity w the beam attains may be observed as an indication of p.*

As in any other pendulum, the length of time occupied in a vibration is almost same whether the vibration be great or small, as may easily be observed to be case.

Fully to understand the motions of a beam, it would be necessary to determin *moment of inertia round the axis*, which is the sum of the moments of each part the moment of inertia being the mass of a particle multiplied by the square of distance from the axis. The velocity of the beam depends on the proportion of force of stability or the force of disturbance, and the moment of inertia, which it ercome. Hence the force of stability alone gives a very imperfect idea of the n of the beam, which will be slower the greater the weight in the pans, espe- if the force of stability itself be not increased, as in the sixth case, by increasing eight in the pans.

e mechanical problem of the balance is not so simple as may at first sight ap- and has not, so far as we are aware, been properly considered dynamically. The em of the compound pendulum, will be found best treated by **Poisson** (Traité échanique, t. ii. c. i. § 3). **Euler**, in the Petersburg Commentaries (x. 3), appears ve shown the statical conditions of a balance.

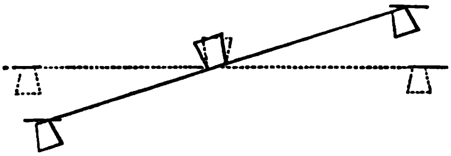
will be apparent that, the length of the beam remaining constant, the properties tical sensibility and stability are reciprocal to each other. By increasing the h of the beam, indeed, the balance is said to be rendered both more sensible and e. But in reality the weight of the beam must be increased in a far greater pro- on than its length, so that its motions will become much slower, to say nothing e less convenience of a large instrument.

e construction in which the three axes are in one straight line, is undoubtedly the perfect, and is especially suitable if the vibrations are to be used, as afterwards ibed, for the determination of fractional weights. But a balance in which the e axis is slightly above the line of the extreme axes, will not become so much r in its movements when heavily laden, and will yet indicate at least as small a on of its load when this is great, as when small. Hence such a balance will, we , be suitable for most purposes. It is necessary however to bear in mind, that the three points of suspension are not in one straight line, equilibrium may st when the beam is not horizontal, and the *weights in the pans are unequal.* For the angle EON is greater than the angle E′ON′, ON and ON′ are unequal, and ay have equilibrium for $P'.\mathrm{ON} = P''.\mathrm{ON}'$, where P' and P'' are unequal weights e pans.

e truth is, that a balance must be so adjusted in its length, strength, weight, elative position of the centres of suspension and gravity, as to combine the exact es of sensibility, stability, or quickness, and capacity for bearing weights, which ecial employment requires. In this adjustment, the chief skill of the balance r consists. Diminution of weight of the beam is an unqualified advantage, as long e strength is sufficient. Thus the employment of aluminium in the construction of ces, will be of great advantage when accomplished; but an aluminium beam, h we have seen, was stated not to be trustworthy in point of strength and in- bility.

e impediment to the free motion of a beam, is usually stated vaguely to be the *on* at the knife edges. But although friction or adhesion may be of some im- nce, the variation in the length of the arms has really a much greater effect. , suppose, as is generally the case, that the knife-edges, instead of being perfectly or round, terminate in very narrow planes (*fig.* 87), of the width x. If the

Fig. 87.



nces between the middle points of the knife edges be a, the real lengths of the two of the lever when the beam is not horizontal, will be $a-x$, and $a+x$, consequently hts which have the ratio of $a+x$, and $a-x$, may be apparently in equilibrium. rder then that a balance with a 20-inch beam may indicate the millionth part of ad, we must at the most have $\frac{1,000,000}{1,000,001} = \frac{a-x}{a+x}$ or $x = \frac{10}{2,000,001}$ inch; within ame length too, the two arms of the beam must be adjusted to equality if the nce is to be accurate within one millionth part of its load. Now this length, g inappreciable in a common microscope, will give some idea of the skill required balance-maker. We are thus prepared too for the statement of Prof. Miller reference below), that he not only detected a difference in the expansion of the arms s balance by a change of temperature, owing to some difference in the quality of the l, but that temperature also affected the sensibility of the instrument, which nbled an *over-compensated pendulum*, from the difference of expansion of the steel e edge and the brass in which it was fixed.

ne resistance of the air has but an inconsiderable effect upon a balance.

Elimination of Errors.—Since every balance however good, requires some d
weight to cause it to turn, a difference of this amount may exist between an
weights which are apparently in equilibrium. Thus if a balance when loaded
to turn with anything less than $\frac{1}{10}$ of a grain, it is an even *chance*, that two w
which do not cause the balance to move, differ by $\frac{1}{20}$ of a grain or more. I
common use of a balance, the turning-weight (*scrupulum* in Latin), will giv
limit of accuracy of the weighings. Let this turning-weight be Δx; then the ba
will turn when the weights $x + \Delta x$ and x are in the pans. It will also probabl
in the opposite direction when $x - \Delta x$ is substituted for $x + \Delta x$, because the ba
unless a very bad one, will turn as easily one way as the other. Thus the m
$x + \Delta x$ and $x - \Delta x$, will be the true weight required, nearly freed from the error
sensibility. This operation may be resorted to when a balance has become insensi
age but is otherwise good, and may be very easily performed by the use of a
weight. But the delicacy of balances is generally ahead of what is required of
Any good balance should weigh with certainty to the $\frac{1}{100000}$ part of its load
there are as yet few chemical operations which can pretend to an accura
$\frac{1}{10000}$ part.

The only other kind of error to which the determinations of a balance are case
liable, is that caused by the inequality of the arms: for the extreme edges can
be adjusted at perfectly equal distances from the centre edge. This error is a
entirely and without trouble, in the ordinary operations of the chemist, by takin
during each analysis or series of experiments, to use, say the left pan invariab
the objects to be weighed, and the right pan for the weights. The apparent w
of all the objects are thus increased or diminished in precisely the same rati
the comparative results are therefore unaffected by the real falsity of the balanc

Thus if *a* be the length of the arm bearing the weight-pan, and *b* the length o
bearing the object-pan, then objects of the true weights, x, y, z, &c. will app
weigh $\frac{b}{a}x$, $\frac{b}{a}y$, $\frac{b}{a}z$, but the ratios $\frac{b}{a}x : \frac{b}{a}y : \frac{b}{a}z$ are the same as $x : y : z$, the
of the true weights. That this elimination of error may be perfect, it is obv
necessary that no weights be placed in the object-pan, as is sometimes done, f
purpose of making up a given weight in the easiest manner by subtraction.

There are, however, two well known methods for obtaining the true absolute
of an object, even by a false balance. The first, introduced by Gauss, proce
simply weighing the object alternately in one pan and the other. If the ap
weights are the same, they are each the true weight, or the balance is appro
correct. If not, the geometric mean is the correct weight, and is found by multi
the true apparent weights together, and taking their square root. For if th
weight be x, and a, b be the lengths of the balance arms as before, $\frac{a}{b}x$, and $\frac{b}{a}$
be the apparent weights in the respective pans, and $x = \sqrt{\frac{a}{b}x \cdot \frac{b}{a}x}$. If the
rent weights be very nearly equal, their common arithmetic mean $\frac{1}{2}\Big(\frac{a}{b}x + \frac{b}{a}$
quite close enough to the truth. Thus the arithmetic mean of 1·000 and 1
1·0005, and the geometric mean 1·0004998 . . . .

The second method for ascertaining absolute weights free from all error, i
known as the *method of substitution*, ascribed by French writers to Borda, bu
bably due to the Père Amiot. If there be one weight C in the weight-pan, and
weights X, Y, Z, &c. be in succession placed in the object-pan, and the balance
always in equilibrium, it is evident that $X = Y = Z = \frac{b}{a}C$. Thus we prov
perfect equality of X, Y, Z, although each of these may differ in an unknown
from C, owing to the inequality of b and a, the lengths of the balance-arms.

To compare the weights of any two objects by this method, counterpoise the g
with the weight C, made up of shot, tin-foil, wire, or any convenient subs
Then substitute the second object for the first, and observe how many small w
must be added to the pan to restore equilibrium with C. The only errors whic
affect such a result will be that of insensibility, and any error which may arise
a minute change of the edges of suspension during the substitution; but these
may be eliminated by taking the mean result of many such operations, a new co
poise being adjusted each time.

But when important weighings have to be made with the most rigorous accura
in the comparison of standard weights, the method of vibrations must be resort
This being a process of pure observation, as distinguished from one of adjust

of unlimited approach to absolute exactness, just as the difference of two
d yards may be ascertained to the $\frac{1}{100000}$ part of an inch, although it would
ssible to make two yards agree within ten times that quantity.

paper by Prof. W. H. Miller, on the Construction of the New Imperial Standard
(Phil. Trans. cxlvi. (1856) p. 753), should be studied by all engaged in exact de-
ations of weights, but a more explicit account of the method of vibrations will
nd in Kupffer's work, "Travaux de la Commission pour fixer les Poids et
s de Russie," St. Petersburg, 1841. Prof. Miller's mode of observing the os-
ns appears to be the most eligible. His balance had a very light ivory scale,
alf an inch long, divided into spaces of about $\frac{1}{100}$ inch, *attached* to the right
the beam. This scale, as it moved, was viewed through a fixed compound
ope, having a single horizontal wire in the focus of the eye-piece. A still more
mode of observation, is by a small mirror fixed to the beam, in which the
on of a divided scale is viewed through a fixed telescope, as in the instruments
gnetical observatory.

weights to be compared being very nearly in equilibrium, the balance when
oscillates slowly through a very small arc, and the extreme points of each
on are to be observed. Supposing the readings thus observed to be R^1, R^2, R^3, R^4.
$\frac{R^1 + 2R^2 + 2R^3 + R^4}{6}$ is the position of equilibrium of the beam: for, by the
of the pendulum already considered, the excursions will be as far on one side as
other. In this expression, R^2 and R^3 are doubled, because they are the end of
f vibration and the beginning of another. Prof. Miller usually rejected the
ding because it is apt to exhibit slight irregularities, and his result was derived
$\frac{{}^2 + 2R^3 + R^4}{4}$. This observation completed, a small known weight is added to
ter of the weights compared, and the new position of equilibrium which the
ends to take up, is observed by a new set of readings. Now the deviation from
izontal position in a good balance being very nearly proportional to the weight
it, we obviously learn from the angular difference of the two positions of the
the deviation corresponding to a given small weight. Hence we learn by
plest calculation the difference of weight corresponding to the deviation in the
servation.

method of weighing by reversal was found more convenient by Prof. Miller,
at by substitution, and was thus practised.

nearly equal weights P and Q to be compared, were weighed directly against
her, but repeatedly reversed, and the balance was so adjusted by a small con-
eight placed in one of the pans or on the beam, that on interchanging P and Q,
tion of equilibrium was still near the middle of the scale. Then if (P, Q) be
ding of the scale in the position of equilibrium when P is in the left hand pan,
n the right hand pan, and (Q, P) the reading when Q is in the left hand pan,
n the right hand pan; then $2Q = 2P + m((P, Q) - (Q, P))$, where m is the
equivalent to one degree of deviation on the scale.

e determination of the equivalents of the elements, and in many physico-
l determinations, it is to be hoped that chemists will soon have to tax to the
these refined methods of weighing.

e balance generally, the reader may further consult Biot, Traité de Physique,
ouillet, El. de Phys. i. 66; Ann. de Chim. xxxvi. 3; Jury Reports on the
ion of 1851, pp. 257—262; Phil. Trans. cxvi. pt. 2, p. 36. For a description
ier's "Automaton-balance" for weighing coin, see *Ure's Dictionary of Arts,*
ctures and Mines, i. 245.
W. S. J.

LUS, or **BALAIS RUBY.** A variety of spinelle, varying in colour from
-white to pale red.

LLESTEROSITE. A variety of iron pyrites, found in Asturia and Gallicia,
gravity 4·75 to 4·90.

LLOON. Receivers and flasks of spherical form are sometimes called balloons.

LSAM. This term, originally confined to a single substance, viz. Balm of
Mecca Balsam, or Balsam of Judea, is now extended to a variety of products,
less resembling that body, but exhibiting considerable diversity of composition
perties. They are viscid, aromatic liquids, which exude from growing plants,
pontaneously, or from incisions made for the purpose.

ams are mixtures of resins with volatile oils, the resins being produced from the
oxidation, so that a balsam may be regarded as an intermediate product be-
a volatile oil and a perfect resin. They may be divided into two groups, the
luding those of purely oleo-resinous character, viz. *Copaiba balsam, Mecca bal-*

sam, and the *balsams* or *turpentines* of coniferous plants; the other group, in ing those which contain cinnamic acid, such as *Peru balsam*, *Tolu balsam*, *Li ambar*, and *Storax*. Benzoin and Dragon's-blood are sometimes also classed ar balsams; but they are more properly resins; the true balsams are liquids more o viscid, and yield volatile oils by distillation with water. The balsams of the se group yield by dry distillation, cinnamate or benzoate of ethyl or methyl, and ac ing to Scharling, these products, or perhaps others not previously existing i balsams, may be formed from them by the action of aqueous alkaline leys.

Balsams of the First Group: Oleo-resins.

CANADA BALSAM or **CANADIAN TURPENTINE**, *Baume du Canada*, is the produ *Abies balsamea* (Dec.), a coniferous tree growing in Canada, Virginia, and Car It collects in vesicles under the bark, and is obtained by making incisions i stem. It is either colourless or slightly yellowish, rather mobile, but tenaciou capable of being drawn into threads, turbid when fresh, but soon becomes per transparent when left at rest. It turns the plane of polarisation of a luminous r the right, and has an index of refraction equal to 1·532. It dries up to a hard va when exposed in thin layers to the air for about forty-eight hours, and grad thickens, even in closed vessels. Its power of hardening, its transparency, an peculiar refractive power, which is nearly the same as that of crown glass, re it very useful as a cement in the construction of optical instruments. In some tries it is used as a medicine; when taken internally, it imparts a nutmeg odour t urine.

Canada balsam distilled with water, yields a volatile oil, of balsamic odour, ing in composition with oil of turpentine (Wirzen), and like that oil, turnin plane of polarisation to the left (Biot); it also leaves a resinous cake, brittle after ing, and consisting of a mixture of several substances. The balsam is partially s in alcohol, a granular resin remaining undissolved.

Canada balsam contains, according to Bonastre (J. Pharm. viii. 572 [1822]) per cent. volatile oil, 40·0 resins easily soluble in alcohol, 33·0 resin sparingly s in alcohol, together with 8·4 caoutchouc and bitter extractive matters soluble in The sparingly soluble resin is described as dry, friable, heavier than water, diffic melt, and becoming electrical by friction. According to Caillot (J. Pharm. xv [1830]), the balsam contains two neutral resins, one called *abietin* (see p. 1), crystallisable and easily soluble in alcohol of 0·824, the other white, pulverulent, out crystalline form, very little soluble in alcohol of 0·824, or in rock oil, or p ley, and closely resembling the sparingly soluble resin obtained from other spec abies; also an acid resin, which forms a coherent paste when mixed with $\frac{1}{1}$ weight of magnesia, and imparts to Canada balsam the property of forming a whit with potash. According to Wirzen (*De balsamis et præsertim de balsamo Can Dissertatio*, Helsingforseæ, 1849), Canada balsam contains 16 per cent. of v oil, 30 pts. of a resin *α*, soluble in boiling alcohol of 0·833, and containing C^{40} (78·31 per cent. C and 10·08 H), 33 pts. of another resin *β*, insoluble in hot al but soluble in ether, and containing $C^{40}H^{30}O^{7}$; and, lastly, 20 pts. of a resin soluble in alcohol and ether. Wirzen's *α* resin is probably a mixture of abietin an acid resin.

A balsam exactly resembling the preceding, excepting that it has a darker c is obtained from *Abies canadensis* (Link). Canada balsam is distinguished fr other varieties of turpentine by its peculiar odour, its perfect transparency and lity, and the facility with which it hardens when exposed to the air. Stra turpentine, from *Abies pectinata*, which very much resembles it, is distinguished optical lævo-rotatory power; and Venice turpentine (from *Larix europæa*), by its and complete solubility in alcohol of ordinary strength, and its indifference to calcined magnesia.

The other balsams, or turpentines, derived from coniferous plants, will be descri the article TURPENTINE.

COPAIBA or **COPAIVA BALSAM**. *Balsamum Copaivæ*, *Baume de Copahu*.— balsam is produced by several species of *Copaifera* (order *Cæsalpineæ*), particula *Copaifera bijugal*, Willd., *C. multijuga*, Hayne, *C. Guianensis*, *C. Langsdorfii*, a *Jacquini*, Desf., which are indigenous in Brazil, Peru, Mexico, and the Antilles. obtained by making incisions or perforations in the trees during rainy weather flows so abundantly that a single incision often yields 12 pounds of the balsam.

Copaiba balsam consists of several resins dissolved in a volatile oil, the amoun nature of the resins varying considerably in balsam from different sources. The three principal varieties, the Brazilian, the Antillian and the Columbian.

Brazilian copaiba is light yellow, generally transparent, of various degrees of

, from mobile to syrupy, and of specific gravity ranging from 0·920 to 0·985.
peculiar, aromatic, disagreeable odour, and a persistently bitter and irritating
By exposure to the air, it becomes darker in colour, of the consistence of tur-
, heavier than water, and ultimately solid and inodorous. When heated in
with the air, it takes fire and burns with a bright, but very smoky flame. The
from the Antilles differs from the Brazilian by its more viscid consistence,
colour, imperfect transparency, and turpentine-like odour. Columbian copaiba
nguished by its turbidity, arising from suspended particles of resin, which are
ed as a crystalline crust when the balsam is left at rest.

chemical examinations hitherto made of copaiba balsam relate chiefly to the
n, of which two varieties are distinguished.

paiba balsam chiefly containing acid resins. — This variety, which was for-
he only one known, is distinguished by the following characters: — It is inso-
water, but imparts to the water its taste and smell. It dissolves in all pro-
in *absolute alcohol*, in *ether*, and in *oils*, both fixed and volatile; the alcoholic
, however, is often rendered turbid by the separation of resinous flakes.
of 90 per cent. dissolves a large quantity of it; alcohol of 80 per cent. only
of its own weight. Mixed with an equal weight of fixed oil, it dissolves in
f 90 per cent. alcohol, the fixed oil separating only on the addition of a con-
le quantity of alcohol. It absorbs *chlorine gas*, becoming turbid at the same
om formation of hydrochloric acid. With *strong sulphuric acid*, it assumes a
our and viscid consistence, with evolution of sulphurous anhydride, and an
f oil of amber. *Strong nitric* acid acts upon it with violence; dilute nitric
re quietly, forming a hard yellow resin, which dissolves partially in the acid,
ellow bitter substance insoluble in water and in alcohol. Distilled with 2 or 3
. of its weight of strong *sulphuric acid* or with *hypochlorite of calcium*, it yields
le oil of fine blue colour (Löwe, Pharm. J. Trans. xiv. 65); the same oil is said
oduced by the action of acid chromate of potassium. Three pts. of the balsam
with 1 pt. of *potash-ley* containing $\frac{1}{8}$ pt. of hydrate of potassium, yield a clear
which does not lose its transparency when mixed with alcohol or with a small
of water, but becomes milky on addition of a large quantity of water. A
uantity of caustic potash-ley added to the clear liquid, throws to the surface a
rent copaiba-soap, which forms a turbid solution with a large quantity of
or with absolute alcohol, but dissolves completely in ether or in hydrated

When an alcoholic solution of the balsam is mixed with dilute potash or soda-
olatile oil rises to the surface, while the resulting compound of resin and alkali
dissolved in the hydrated alcohol. This process may be used for the prepara-
the volatile oil. Five pts. of the balsam form with 2 pts. of aqueous *ammonia*
fic gravity 0·921, a clear mixture, from which a larger quantity of ammonia
s a soapy compound. A mixture of 9 pts. of the balsam and 2 pts. aqueous
a well shaken up and left at rest at + 10° C., gradually yields a crystalline
consisting of the resinous acid of the balsam. The balsam likewise combines
with *magnesia*. It dissolves completely $\frac{1}{50}$ of its weight of calcined magnesia,
en mixed with $\frac{1}{16}$ of its weight of that substance, thickens to a stiff paste in the
of a few days; with $\frac{1}{8}$ in a few hours. Similarly with *quick lime*. Carbonate
nesium likewise forms with 4 pts. of the pure balsam at mean temperatures
or 60° F.), a clear viscid solution.

balsam distilled with *water* yields a volatile mobile oil, C^5H^8, possessing in a
gree the peculiar odour of the balsam, and forming a crystalline compound
ydrochloric acid (see COPAIBA OIL), while in the retort there remains a mass
le resin, which is resolved by treatment with rock-oil, into a crystallisable por-
uble in that liquid (the α resin of Berzelius), and an insoluble unctuous sub-
(β resin of Berzelius). The crystallisable resin has the formula $C^{20}H^{30}O^2$, and
property of reddening litmus and uniting readily with acids, is called *copaivic*
The crystalline deposit which separates from the turbid balsam, is, according to
's investigation, a resinous acid containing $C^{20}H^{28}O^3$. It is to these two
that the peculiar reactions of the balsam with bases are due. The soft resin
aps, formed by oxidation of the volatile oil in the air, and appears to have but
slight affinity for bases, inasmuch as when isolated it dissolves but slowly, and
ith the aid of heat, in potash and ammonia, forming a turbid solution. (See
A RESINS.)

les these essential constituents, the balsam likewise contains occasionally a
quantity of water, and, according to Durand, small quantities of extractive
acetic acid (perhaps also succinic acid), and a fatty substance, which re-
behind when the balsam is dissolved in alcohol of specific gravity 0·842; also
of chloride of calcium. The following are analyses of this variety of copaiba
:

	Stoltze.[*]	Guibourt.[†]	Gerber.[‡]	
			Fresh balsam.	Old balsam
Volatile oil . .	38·00	45·0	41·0	31·97
Alpha-resin . .	52·75	53·9	51·38	52·68
Beta-resin . .	1·66	1·1	2·18	11·15
Water and loss . .	7·59		5·44	4·10
	100·00	100·0	100·00	100·00

II. *Copaiba Balsam, containing only neutral resins.* PARACOPAIBA BALSAM.— variety, which is of recent introduction, is distinguished from the former by its greater mobility. In odour and taste it agrees with the preceding, but, accordi Posselt (Ann. Ch. Pharm. lxix. 67), behaves in a totally different manner wit vents and with bases. With alcohol, in any proportion, it forms a turbid mi Potash and ammonia also form with it turbid liniments, which, when left at deposit the balsam in its original state. It does not thicken with magnesia. volatile oil, *paracopaiba-oil*, which it yields by distillation with water, is distingu from the copaiba-oil above-mentioned, by its viscidity, its sparing solubility in lute alcohol, and especially by not forming a crystalline compound with hydroc acid. The resinous cake, brittle in the cold, which remains after the volatile oi been distilled off, is resolved by cold alcohol into a soluble portion, which sep on evaporation of the alcohol, in drops that gradually solidify in amorphous m and another resin, which dissolves only in boiling alcohol and in ether, is diffic fuse, and likewise uncrystallisable. Neither of these resins exhibits any acid rea in the state of solution, or forms compounds with bases (see COPAIBA RESINS). hundred pts. of the Brazilian balsam examined by Posselt, contained 82 pts. of vo oil, and 18 pts. resin, the greater part of which was soluble in cold alcohol.

The two varieties of copaiba balsam just described, the first of which, from it haviour with magnesia, is called *solidifiable balsam*, must be regarded mere types—which are, perhaps, not the only ones—and may vary greatly in the propo of oil and resin, and therefore in consistence. Oberdörffer (Arch. Pharm. [2 172) found in three varieties of mobile copaiba balsam of the first variety:

	I.	II.	III.
Volatile oil	60	58	54
Resins	40	42	46

The following proportions of oil and resin have been found in several balsa unknown origin:

	Ulex.[§]	Stockhardt.[‖]		Procter.[¶]				
	IV.	V.	VI.	VII.	VIII.	IX.	X.	X
Specific gravity	0·928			0·916	0·956	0·983	0·985	0·9
Volatile oil .	90	58	56·5	80	65	50	35	
Resins . .	11	42	43·5	20	35	50	65	

The amount of volatile oil was estimated either by the loss of weight whic balsams suffered by boiling with water (I. to VI.), or by continued heating to 12 (248° F.), till the weight remained constant (VII. to XI). The balsams IV. t were mobile and are not further distinguished; VII. and VIII. are mobile balsa the second variety; IX. to XI. viscid balsams of the first variety.

According to Procter. the proportion of oil varies with the age of the trees youngest trees yielding the most liquid balsam. The acid resins appear to be fo in the plant itself, while the soft resin (β resin) is produced by the oxidation o volatile oil, and consequently increases in amount with the age of the balsam, cially when it is kept in loosely closed vessels; this is in accordance with the re of Oberdörffer's analyses just quoted.

Copaiba balsam is used in the preparation of lac-varnishes and tracing paper its chief application is in medicine, as a remedy in diseases of the urinary pass It is not known with certainty to which constituent of the balsam the peculiar ph logical action is due; but it does not appear to reside especially in the volatile oil in many places, the resin completely freed from oil is successfully used in me practice, instead of the balsam in its original state. Whether the more oleag variety, containing only neutral resins, which is of recent introduction, is capab exerting the same action as the more viscid and acid variety, which has long bee use, is not yet known.

Copaiba balsam is often adulterated, especially with-fixed oils and turpentines.

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[*] Berliner Jahrb. f. Pharm. xxvii. 179.

[†] Pharm. J. Trans. x. 172.

[‡] Brande's Archiv, xxx. 147.

[§] Arch. Pharm. cxxii. 14.

[‖] Arch. Pharm. xxxviii. 12.

[¶] Pharm. J. Trans. x. 683

rars East Indian *wood-oil* (also called *Gurjun balsam*, or *capivi*), which closely bles copaiba balsam in taste and smell, has been introduced as a substitute for it. oil may be easily distinguished by its property of becoming gelatinous when d to 130° C. (268° F.), whereas pure copaiba balsam becomes more fluid when d.

e presence of fixed oils in copaiba balsam may be detected by the following ods:—1. By placing one or two drops of the balsam on paper, and evaporating it ery gentle heat. The pure balsam then leaves a hard, sharply defined varnish-pot, whereas if any fixed oil be present, the spot is soft and surrounded with a of fat (Berzelius).—2. The pure balsam, boiled for some hours with water in an vessel, leaves a resin which becomes brittle on cooling: fixed oils render this e soft or greasy.—3. The fixed oils remain behind when the balsam is dissolved pts. of alcohol of 90 per cent. (a smaller quantity of alcohol of that strength l leave some of the balsam undissolved, p. 493). This last method will not in- the presence of castor-oil, which is itself soluble in alcohol; neither will it detect resence of less than 10 per cent. of other fixed oils. Turpentine and oil of tur-ne may be recognised by their odour, especially when the balsam is dropped upon al plate.

other methods of testing copaiba balsam are founded on the amount of acid contained in it, and relate to the first variety (p. 493). This officinal balsam be regarded as genuine when, besides exhibiting the characters above mentioned 93), it forms a clear or nearly clear solution with alcohol, yields by distillation water, not more than 45 per cent. of volatile oil; forms a clear solution with $\frac{3}{8}$ of eight of aqueous ammonia of specific gravity 0·921, and when mixed with $\frac{1}{16}$ of eight of calcined magnesia, gradually forms (in twenty-four to forty-eight hours) stic paste. (Handwört. d. Chem. 2^{te} Aufl. ii. 634.)

CCA BALSAM OR BALM OF GILEAD. *Opobalsamum verum s. gileadense. Baume Mecque, de Judée, ou du Caire.*—This balsam is the produce of the *Balsamo-ron gileadense* or, *Amyris gileadensis*, a shrub belonging to the terebenthaceous , native of Arabia Felix. There appear to be three varieties of it. The finest, is used only in the East, and has a peculiarly fragrant odour, is said to exude from lowers in clear colourless drops. An inferior sort exudes spontaneously, or from ons in the young branches of the plant. It is mobile, pale yellow, turbid like nd syrup, has a very agreeable odour like rosemary and lemon, and a bitterish taste. When exposed to the air, it gradually hardens and loses its transparency. third sort, which is the most common, is obtained by boiling the wood and the ches with water. It is somewhat more viscid than balsam of copaiba, becomes and soapy when rubbed in the hand, and when dropped upon water, forms a which is easily removed by a quill feather. Ordinary spirit of wine dissolves it partially, and leaves a transparent odorous substance, of which warm alcohol of fic gravity 0·815 dissolves about two-thirds. The residue is a flocculent sub-e, which may be drawn out into threads.

rommsdorff (Trommsd. Neues Journal, xvi. 62) found in a sample of this balsam, er cent. of volatile oil, 64 per cent. of hard resin, 4 per cent. of soft resin, and 0·4 ent. of bitter principles. The *volatile oil* was mobile, colourless, fragrant, and a rough taste; dissolved in alcohol and ether, and with deep red colour in sul-ic acid, whence it was precipitated by water as a resin. It was also resinised by c acid. The *hard resin* was honey-yellow, transparent, brittle, of specific gravity 3, softened at 44° C., and melted completely at 90°. It dissolved with difficulty cohol and ether at ordinary temperatures, easily with aid of heat; it was likewise le in oils, both fixed and volatile. It was altered by hot nitric and sulphuric , and appeared to combine with alkalis, forming compounds insoluble in free i. The *soft resin* was brown and very glutinous, inodorous and tasteless; melted, dry, at 112° C. It was insoluble in alcohol and ether, but soluble in oils, both and volatile. It was not attacked by alkalis or by strong sulphuric acid; with c acid, it swelled up and became friable.

cording to Bonastre (Ann. Ch. Pharm. iii. 147), Mecca balsam contains in pts.:

Fragrant volatile oil	10 pts.
Brown bitter extract, soluble in water and alcohol	4 „
Acid resin, soluble in alcohol, and not hardening	70 „
Stiff whitish-grey resin, sparingly soluble in alcohol	12 „
Acid substance and impurities	4 „

ecca balsam was formerly used in medicine, but has now fallen into disuse on unt of its scarcity and dearness. In the East it is used internally as a tonic.

Balsams of the Second Group, containing Cinnamic Acid.

Liquidambar Balsam is the produce of *Liquidambar styraciflua*, a large tree g ing in Louisiana, Florida, and Mexico. There are two varieties of it, viz.:

1. *Liquid liquidambar*, or *Oil of liquidambar*, which is obtained by making sions in the tree, receiving the balsam immediately, in vessels which protect it the action of the air, and afterwards decanting the liquid from a portion of op balsam, which settles to the bottom. It is a thick transparent oil of amber-y colour, has an odour like that of liquid storax, but more agreeable, and an aro taste, which irritates the throat. It contains a rather large quantity of benzo cinnamic acid, and reddens litmus paper strongly. Boiling alcohol dissolves it, exception of a slight residue, and the filtered liquid becomes turbid on cooling.

2. *Soft* or *white liquidambar* is formed from the preceding by exposure to the a when it runs down the stem of the tree and is left there to thicken. It resem very thick turpentine or soft pitch, is opaque and whitish, has a less powerful more agreeable odour than the preceding, and a sweet, perfumed, but irritating It contains a large quantity of benzoic or cinnamic acid. By continued exposu the air, it solidifies completely, and becomes nearly transparent. It was formerly as white Peru balsam. (Gerh. iii. 386.)

Peru Balsam. *Balsamum peruvianum; Bals. indicum.*—This balsam is produce of certain species of *Myroxylum*, or *Myrospermum*, growing on the B coast near San Sonate, in the state of San Salvador, Central America. There are varieties of it:

1. **White Peru balsam.**—Obtained from the fruit of the tree by removing wings and the outer and middle integuments, and subjecting the inner coating, tog with the seed, to pressure. The balsam thus obtained is pale yellow, somewhat turbid and granular, and has an agreeable odour of melilot. When left at re deposits a solid crystalline layer. Cold alcohol or ether dissolves it but imperfe the same liquids when hot dissolve the greater portion. The alcoholic solution, left at rest, deposits crystals of myroxocarpin (*q.v.*), of which also the cryst sediment above mentioned appears to consist. The ethereal extract of the b leaves when evaporated a mixture of resin and fixed oil. The balsam distilled water, yields traces of a volatile oil and a volatile acid (Scharling). Accordi Guibourt, there is another kind of white Peru balsam, which is identical with li ambar.

2. **Dry Peru balsam**, *Balsamum peruvianum siccum*, *Opobalsamum siccu* said to be produced from the preceding by hardening in contact with the air. cording to Weddell, it exudes spontaneously from the stem of a myroxylum. reddish-yellow, translucent, hard, smells aromatic and like vanilla, melts when h and burns with a smoky flame; 100 pts. of it contain, according to Tromsdorff, 1 benzoic (more probably cinnamic) acid, 0·2 volatile oil, and 88·0 resin.

3. **Black Peru balsam.** Black balsam of San Salvador or San Sonate. *Bals peruvianum* s. *indicum nigrum*. *Baume de Pérou noir*. This, which is the ordi Peru balsam, has been known in Europe since 1580. It is said to be obtained by m incisions in the stem of the trees, partially detaching a portion of the bark in s manner as to leave it still connected with the stem at the upper part, then thrusting wo rags between the bark and the wood, and warming the tree by making a fire rou Fresh incisions are then made higher and higher up, till the rags are saturated process occupying ten or twelve days. The cloths impregnated with balsam are removed, and well boiled with water, and the balsam which sinks to the botto freed from water, which it retains somewhat firmly, by several hours boiling water. It is then further purified by straining, and sent to Europe by way of whence its name. (Copious details of the history and preparation of this balsam given in *Muspratt's Chemistry*, i. 228; see also *Ure's Dictionary of Arts, M factures and Mines*, i. 248.)

Black Peru balsam is viscid but not glutinous, of dark brown colour, opaque i mass, but in thin layers perfectly transparent, with brown-red colour. Specific gr 1·15. In contact with the air, it gradually thickens, but does not solidify. It h agreeable odour, like vanilla, a bitter, persistently irritating taste, and an acid reac 1000 parts of the balsam saturating about 75 of carbonate of sodium.

When heated, it takes fire and burns with a smoky flame. When distilled with it does not yield any volatile oil, but the distillate contains cinnamic acid, which in the balsam in the free state, and may be extracted by repeated boiling with or by carbonate of sodium. Peru balsam mixes in all proportions with *absolute alc* but the solution is not quite clear, and deposits a flocculent substance when left at Weaker alcohol dissolves it less easily, and leaves a residue of resin. It is als incompletely soluble in *ether* and in *oils*, whether fixed or volatile. It mixes wi

ity with $\frac{1}{8}$ of its weight of fixed oil, or with $\frac{1}{4}$ of its weight of balsam of copaiba;
a larger quantity of either of these liquids be added, two layers are formed.
uric *acid* converts it into a thick red mass, with evolution of sulphurous acid;
acid acts upon it only when heated, giving off nitrous fumes and hydrocyanic
after the evaporation of the mixture, there remains a brownish-yellow bitter
nce, soluble in water. When 2 volumes of the balsam are gently heated with
mes of *potash-ley*, of specific gravity 1·3, two layers of liquid are formed, the
consisting of a brownish oil (oil of Peru balsam), and the lower, which is watery,
ning cinnamic acid, resins, and colouring matters in combination with potash.
of the balsam form a soapy mixture with 1 pt. hydrate of potassium and 1 pt. of

When subjected to *dry distillation*, it begins to boil at 287° C. and yields,
ontinual rise of temperature, an oil coloured by products of decomposition, while
us charcoal remains in the retort.

ck Peru balsam has been repeatedly analysed. The earliest examination of it
nade in 1824, by Stoltze (Berliner. Jahrb. f. Pharm. xxv. 24), who found in
ts. 69·0 pts. of a peculiar volatile oil, 6·4 of acid (supposed at the time to be
c acid, but really consisting of cinnamic acid), 20·7 resin easily soluble in
l, 2·4 resin sparingly soluble in alcohol, 0·6 extractive matter, and 0·9 moisture.

ording to Fremy (Ann. Ch. Phys. [2] lxx. 180), the balsam is composed of
le quantities of a volatile oil (*cinnamein* or *styracin*), a crystallisable substance
cinnamein), isomeric therewith, *cinnamic acid*, and *resin*. On dissolving the
n in alcohol, and adding alcoholic potash, the resin is precipitated in combination
potash, while the cinnamein remains dissolved, and may be precipitated by
the cinnamic acid still remaining in solution. The oil is purified from resin by
on in rock-oil and evaporation; by exposing it to a low temperature, and redis-
g in weak alcohol, the crystalline metacinnamein, which however is not always
t, is separated (see CINNAMEIN). The resinous portion of the balsam appears to
nixture of several distinct resins, one of which agrees in composition with the
produced from cinnamein by the action of sulphuric acid; another differs from
ust mentioned merely by containing a smaller amount of the elements of water.
therefore regards cinnamein and metacinnamein as the original constituents
u balsam, the cinnamic acid as a product of oxidation, and the resins as hydrates
namein. This view explains the variation in constitution of the balsam with
lso the fact that cinnamic acid is still present in the balsam after it has been
with water, and increases in quantity with the age of the balsam.

Plantamour's results, which agree with those of Fremy, so far as regards the
ce of cinnamein and cinnamic acid, see Ann. Ch. Pharm. xxvii. 329; xxx. 347.
ding to Scharling (*ibid.* xcvii. 168), the cinnamein obtained from different
es of Peru balsam is not of constant composition; but the formulæ which he
s to them are improbable.

resin of Peru balsam mixed with pumice and subjected to dry distillation, yields
ic acid, together with an oily and a watery distillate. On distilling the former
elf, a lighter oil passes over at 175° C., and afterwards a heavy liquid, which
to the bottom. The light oil, repeatedly rectified with potash-ley, and finally
ydrate of potassium, yields pure cinnamene, C^8H^8. The heavier liquid appears to
t of benzoate of methyl and phenic acid: when distilled with potash-ley, it yields
spirit. (Scharling, *loc. cit.*)

ck Peru balsam is used in medicine as an application to wounds, and also as an
al remedy. It is also used in perfumery, and in the preparation of chocolate, as
stitute for vanilla. The white and dry balsams (p. 496) are scarce, and have
ceived any practical application.

lterations in Peru balsam may be detected as follows: *Fixed oils* remain un-
ved on treating the balsam with strong alcohol; *volatile oils* lower the boiling
and pass over on distilling the balsam with water; *copaiba balsam* and *tur-*
e may be recognised by the odour which they give out when heated; also by
ng volatile oils on distillation with water; *sugar* and all substances soluble in
by the diminution of volume which the balsam so adulterated undergoes when
n up with water; syrup of sugar also renders the balsam turbid.

RAX BALSAM.—This balsam is the produce of *Styrax officinalis*, a shrub
ng in the Levant, Palestine, Syria, and Greece. It is imported into Europe
Trieste. There are two principal varieties of it, *Styrax liquidus*, and *Styrax*
ta.

iquid storax.—This variety is sometimes transparent, of brownish-yellow colour,
consistence and tenacity of Venice turpentine, and has a peculiar sweetish or
-like odour; sometimes opaque, with grey colour, the consistence of bird-lime,
strong oppressive odour, slightly mixed with that of benzene or naphthalene.
storax is a mixture of styrol, cinnamic acid, styracin, and resins.

b. ***Reed storax, Styrax calamita.***—This is imported in compact masses of fragr odour and rich brown colour, interspersed with white tears, whence it has also b called *amygdaloïd storax*. According to Reinsch, it contains about 0·5 per cent volatile oil, 33 to 54 per cent. resin, 1·1 to 2·6 benzoic acid, 8 to 14 gum and extra 9·6 to 24 matter extracted by potash, 20 to 27 woody fibre, 5 water, and traces ammonia. The drug sold under this name is, however, of very variable compositi often consisting of nothing but saw-dust or decayed wood, impregnated with c tar, or some similar substance, and bearing no resemblance whatever to the genu storax.

Storax is used in medicine, as a stimulating expectorant, its operation be analogous to that of Peru balsam or benzoin. It is also used as a detergent, in form of ointment. (Muspratt's Chemistry, i. 225.)

TOLU BALSAM.—This balsam is obtained in large quantity from incisions in stem of the *Myrospermum toluiferum* (Sprengel), *Myroxylum toluiferum* (Richar a tree growing in various districts of Columbia, viz. in the mountains of Turb and Tolu, and on the Magdalena River. In the fresh state it is yellowish, tra parent and liquid, like turpentine (*white tolu-balsam*) but changes rather quickly keeping, acquiring a reddish-brown colour and stiff consistence (*black tolu-balsam*), being ultimately converted into a friable substance of granular crystalline struct (*dry tolu-balsam*). It has an aromatic odour, like that of lemon and jasmine, an sweetish, aromatic, somewhat irritating taste. It melts at a gentle heat; disso readily and completely in *alcohol*; less readily in *ether* and in *volatile oils*; not c pletely in *fixed oils*. Hot *water* extracts from it cinnamic acid (and, accordin Deville and Scharling, likewise benzoic acid), together with volatile oil. Heated w strong *sulphuric acid*, it forms a red solution without giving off sulphurous acid. W *potash-ley* of specific gravity 1·17, it forms a clear solution having an odour of viol and with drops of oil floating on the surface.

Tolu balsam is a mixture of volatile oil, free acid, and resin. The *volatile oil* is tained by distilling the balsam with water, the quantity being always small, varying according to the age of the balsam. Deville obtained 0·2 per cent., Scharl 1 per cent., and, by afterwards passing steam heated to 170° C. through the bals 0·2 per cent. more. This oil is, according to Deville, a mixture of *tolene*, $C^{12}H^{18}$, p ing over betweeen 160° and 170° C., and *cinnamein*, $C^{16}H^{14}O^2$, which distils betw 340° and 350° C. According to E. Kopp and Scharling, on the other hand, the consists wholly of tolene, which, according to Kopp, is isomeric with oil of turpent $C^{10}H^{16}$. The small quantity of volatile oil contained in Tolu balsam, and the rapid with which it hardens by exposure to the air, are characters by which it is read distinguished from balsam of Peru.

The free acid of Tolu balsam consists, according to Deville and Scharling, of c *namic* and *benzoic* acids; according to Frémy and E. Kopp, of cinnamic acid o The balsam boiled with water, yields a solution which, on cooling, deposits cryst chiefly of cinnamic acid (Deville). The oil obtained by distilling the balsam w water, and cohobating the distillate several times, deposits benzoic acid when expo to the air (Deville). Benzoic acid is likewise extracted, together with cinnamic a by treating the balsam with aqueous carbonate of sodium, or caustic potash, add chloride of calcium to precipitate the resins, and supersaturating the filtrate with drochloric acid (Deville, Scharling). E. Kopp is of opinion that the benzoic a is a product of decomposition, and does not pre-exist in the balsam.

Resins.—According to E. Kopp, Tolu balsam contains two resins, an α resin, eas soluble in alcohol, and a β resin, $C^{18}H^{20}O^5$, sparingly soluble in alcohol.

The α resin, $C^{18}H^{19}O^4$, according to Köpp, but more probably $C^{18}H^{18}O^4$, as sugges by Gerhardt (Traité, iii. 408), is obtained by treating the balsam with cold alcol after it has been freed from volatile oil and cinnamic acid by distillation and boil with water. It is brown, translucent, and shining; friable in the cold; but powder cakes together even at + 15° C., and the resin melts at 60° C. Strong s phuric acid colours it purple-red. When dissolved in potash-ley, and exposed to air, it oxidises readily, and is converted into β resin. By dry distillation it yie toluene and benzoic acid.

The β resin, $C^{18}H^{20}O^5$, is brownish, dull, and without taste or smell; melts a temperature above 100° C. It is sparingly soluble in alcohol and ether, dissolves w brown colour in potash-ley, and is precipitated with violet colour by sulphuric ac It is more permanent than the α resin.

The mixture of the two resins, treated with nitric acid, yields a number of vola and gaseous products, consisting of carbonic anhydride, nitrous anhydride, nitric oxi bitter-almond oil, hydrocyanic acid, and a small quantity of benzoic acid, and th remains a yellow mass, consisting of benzoic acid and a yellow resinous colour matter, which prevents the benzoic acid from crystallising till it has been separated blimation. The resin thus treated yields about a third of its weight of pure benzoic id.

According to Deville, Tolu balsam contains only one kind of resin, which has the mposition of the β resin just described. To extract it, Deville dissolves the balsam potash largely diluted with water, saturates the liquid with carbonic acid gas, hereby a small quantity of resin is precipitated, then adds chloride of calcium, which ecipitates the carbonic acid and the rest of the resin as calcium-salts, leaving benzoic d cinnamic acids in solution. The rose-coloured mass, left after filtration, is then eated with hydrochloric acid, which dissolves out the lime and leaves the resin, and e latter is purified by solution in a small quantity of alcohol and precipitation by ater. It then forms a rose-coloured powder, having a faint odour of vanilla, soluble alcohol and in potash, very hygrometric, and varying considerably in colour from e effect of atmospheric influences, and perhaps also of light. Treated with fuming tric acid, it takes fire and burns as in oxygen. By dry distillation, it yields a small antity of water, benzoic acid, toluol, benzoate of ethyl, and a mixture of carbonic ide and carbonic anhydride. (Deville.)

Scharling finds that, when the resins of Tolu balsam are mixed with half their ight of powdered pumice, and covered in the retort with a layer of pumice, the ocess of dry distillation goes on quietly and without tumefaction. 16 pts. of the sin heated in this manner, ultimately to redness, yield 2 pts. of a watery, and 5 pts. an oily liquid, which is heavier than water, and is resolved by fractional distillation to toluol, phenic acid, and a portion boiling above 198° C. The latter was not obined of constant boiling point, and yielded by analysis numbers intermediate tween the composition of benzoate of ethyl, $C^7H^5(C^2H^5)O^2$, and benzoate of methyl, $H^5(CH^3)O^2$. When distilled with potash, however, it yielded only methylic alcohol, thout any common alcohol; hence it appears that the products of distillation of the sins are toluene, phenic acid, and benzoate of methyl.

The mode of formation of Tolu balsam is not known with certainty. If we regard nnamein as the primary constituent, the resins α and β may be formed from it by sorption of oxygen and water:

$$\underset{\alpha\ \text{resin.}}{C^{18}H^{18}O^4} = \underset{\text{Cinnamein.}}{C^{16}H^{14}O^2} + O + H^2O$$

$$\underset{\beta\ \text{resin.}}{C^{18}H^{20}O^5} = C^{16}H^{14}O^2 + O + 2H^2O$$

the α resin may be converted by oxidation into the β resin and cinnamic acid:

$$\underset{\alpha\ \text{resin.}}{2C^{18}H^{18}O^4} + O = \underset{\beta\ \text{resin.}}{C^{18}H^{20}O^5} + \underset{\text{Cinnamic acid.}}{2C^9H^8O^2}$$

stly, the β resin may split up into benzoic acid, water, and a hydrocarbon:

$$C^{18}H^{20}O^5 = 2C^7H^6O^2 + H^2O + C^4H^6$$

ich hydrocarbon is supposed by E. Kopp to give rise to the formation of tolene. harling, on the other hand, supposes that all the constituents of the balsam are rmed from tolene, inasmuch as this body, when exposed to the air, quickly becomes sinous and acquires an acid reaction. It must be observed, however, that the resins us formed are very different in composition and properties from those of Tolu balsam, d the nature of the acid has not been determined.

Tolu balsam is used medicinally to facilitate expectoration in coughs and chronic tarrhs; also in perfumery. It is said to be often adulterated with liquid storax, uidambar, and Canada balsam. Pure Tolu balsam may be known by its perfect nsparency when fresh; by its odour; by its freedom from water; by its perfect solulity in potash-ley of 1·17, and in alcohol; and by its reaction with sulphuric acid.

BALSAMS, ARTIFICIAL. Pharmaceutical preparations, chiefly for external e, and somewhat resembling the natural balsams in their physical character, g. *Balsamum opodeldoc*, an alcoholic soap-solution containing ammonia; *Balsamum rcæi*, a salve containing elemi-resin; *Balsamum sulphuris*, a solution of sulphur in nseed oil, &c.

BALTIMORITE. A variety of chrysotil, or fibrous serpentine, found at Baltire in North America.

BAMLITE. A silicate of aluminium, found in microscopic linear or fibrous ystals, at Bamle in Norway. Specific gravity 2·984; hardness about equal to that disthene; colour varying from white to pale greenish; lustre vitreous to silky; anslucent, or in single individuals nearly transparent and colourless. According to rdmann's analysis (J. pr. Chem. xxxi. 165) it contains 56·9 silica, 40·72 alumina, 1·04 ferric oxide, 1·04 lime, and traces of fluorine, numbers which correspond nearl to the formula $Si^9Al^8O^{30} = 4Al^2O^3.9SiO^2$; but it requires further examinatio Kobell regards it as a mixture of disthene and quartz.

BARALITE or **BAVALITE.** A mineral from Baralon, Côte du Nord, co taining silica, alumina, ferric oxide, lime, magnesia, and water. It is probably mixture, the separate constituents of which are not distinguishable by the eye.

BARBATIMAO. A name applied to several Brazilian barks containing tanni and used both as astringent medicines and in the tanning of leather.

BARDIGLIONE. A blue variety of anhydrite cut and polished for variou ornamental purposes.

BAREGIN. *Glairin.*—A nitrogenous substance contained in sulphurous therm springs, especially in France. It forms a deposit on the sides of the basins an conduits of the springs, which are sometimes filled with water and sometimes empt never occurring in parts which are constantly full. The name baregin is derived fro its occurrence at Barèges; it is also called *Plombierin*, from Plombières, anothe locality in which it is found in considerable quantity. Baregin is in the moist sta a transparent, gelatinous, nearly colourless substance, destitute of taste and odou It dissolves very sparingly in the cold, more readily at higher temperatures, in wate alcohol, aqueous acids, and alkalis, and in oil of turpentine; insoluble in ethe When dried, it forms a horny mass, and on heating this mass, it emits an odour lil that of burnt horn, together with ammoniacal vapours. According to Bouis (Comp rend. xli. 16) it contains from 44 to 48·7 per cent. of carbon, 6·7 to 7·7 hydroge 5·6 to 8·1 nitrogen, and 30·2 to 40·7 per cent. of ash, chiefly consisting of silica. does not contain sulphur. According to Danberg, it consists for the most part of mass of confervæ and oscillatoriæ.

Nearly allied to, if not identical with baregin, is a substance which is sometim formed in the quick method of preparing vinegar (see ACETIC ACID, p. 7), and attach itself in gelatinous shreds to the inside of the perforated casks. This substance whe dried forms a parchment-like layer, containing 42 per cent. carbon and 6 hydroge besides nitrogen and oxygen, and leaving an alkaline ash. (Gerh. iv. 536; Handv d. Chem. 2te Aufl. ii. 643.)

BARILLA or **BARILLOR.** The term given in commerce to the impure sod imported from Spain and the Levant. It is made by burning to ashes different plan that grow on the sea shore, chiefly of the genus *Salsola*, and is imported in ha porous masses of a speckled brown colour. *Kelp*, a still more impure alkali, made i this country by burning various sea-weeds, is sometimes called *British barilla*. The substances were formerly the source of all the soda of commerce; but their use now almost entirely superseded by the manufacture of soda from common salt.

BARIUM. *Symbol* Ba; *Atomic weight* 137.—(The name is derived from *βαρ* heavy, in allusion to the great density of its compounds.) This metal occurs abu dantly as a sulphate and carbonate; also in the mineral *barytocalcite*, a carbonate barium and calcium, in certain ores of manganese, in Harmotome and in Brewsterit traces of it has also been found in mineral waters. It is never found native. T oxide, *baryta*, was first recognised as a peculiar earth, distinct from lime, by Schee in 1774; and the metal itself was first obtained by Davy, in 1808.

Preparation.—1. Hydrate of barium, or the carbonate, chloride, or nitrate, is ma into a doughy mass with water, formed into a cup, and placed upon a platinum dis which is connected with the positive pole of a voltaic battery of 500 pairs of plate the cup being filled with mercury, into which the negative wire dips. The amalga of barium thus obtained is heated in a tube of glass without lead, filled with t vapour of rock-oil, till all the mercury is sublimed (Sir H. Davy). If the hydrate barium is mixed with oxide of mercury, the amalgam is obtained in larger quanti (Sir H. Davy.) Hare (J. pr. Chem. xix. 249) prepared the amalgam in a simil manner from moistened chloride of barium surrounded by a freezing mixture, usi two batteries, each of 100 pairs, and containing more than 100 square feet of zi The mercury was expelled by heating the amalgam in an iron crucible provided wi an iron cover, and exhausted of air.—2. Barium may be obtained in an impure sta according to Davy, by passing vapour of potassium over red-hot baryta or chloride barium.—3. Pure baryta or the nitrate is placed in a hole made in a piece of charc or slate, and exposed to a burning jet of detonating gas, produced from three measur of hydrogen and one measure of oxygen gas. Effervescence takes place, and whit shining little globules of metallic barium are formed. The baryta must be anhydro and the detonating gas must be passed through oil and not through water; otherwise translucent vitreous or horny mass will be obtained. (Clarke, Ann. Phil. xvii. 419 —4. Bunsen subjects chloride of barium, mixed up to a paste with water and a litt

chloric acid, at a temperature of 100° C., to the action of the electric current,
an amalgamated platinum wire as the negative pole. In this manner, the metal
ained as a solid, silver-white highly crystalline amalgam, which, when placed in a
boat made of thoroughly ignited charcoal, and heated in a stream of hydrogen,
barium in the form of a tumefied mass, tarnished on the surface, but often
iting a silver-white lustre in the cavities (Pogg. Ann. xci. 619). **Matthiessen**
btained barium by a method similar to that adopted for strontium (*q. v.*); but
n the form of a metallic powder.

perties.—Barium, according to Davy, is a silver-white metal with less lustre than
ron; according to Clarke, it has the colour and lustre of iron; according to
iessen, it is a yellow powder. It sinks rapidly in strong sulphuric acid, even
surrounded by bubbles of gas. Its specific gravity, according to Clarke, is 4·0
newhat greater. It is ductile, and may be beaten flat, though with difficulty.
lts below redness, and does not volatilise at a red heat. It oxidises rapidly in
ir, becoming heated at the same time, and decomposes water rapidly at ordinary
eratures. When heated in the air, it burns with a dark red light (**Davy**); before
xy-hydrogen blowpipe it burns with a greenish flame (**Clarke**). Sulphuric
apidly converts it into sulphate, with evolution of hydrogen.

ARIUM, BROMIDE OF. BaBr. *Crystallised*, $BaBr^2.2H^2O$.—Prepared by
ting baryta-water, or sulphide, or carbonate of barium with hydrobromic acid,
decomposing the sulphide with free bromine, sulphur being at the same time
itated. It is very soluble in water and crystallises with difficulty. Isomor-
with the chloride. It is soluble in strong alcohol, and may thus be separated
the chloride, which is nearly insoluble in that liquid.

ARIUM, CHLORIDE OF. BaCl. *Crystallised*, $BaCl^2.2H^2O$.—The hydrated
as formerly called *Terra ponderosa salita.* This salt is prepared either from
rbonate or from the sulphate of barium, both of which are natural minerals.
arbonate (witherite) is simply dissolved in hydrochloric acid, and the resulting
de purified by recrystallisation. From the native sulphate (heavy spar), the
de may be prepared in two ways: 1. By igniting the sulphate in a crucible with
led coal, whereby it is converted into sulphide, $Ba''S$, extracting the sulphide by
g water, and decomposing the filtered solution with hydrochloric acid:

$$Ba''S + 2HCl = Ba''Cl^2 + H^2S.$$

cid is added in sufficient quantity to produce a strong acid reaction, and the liquid
led for some time to drive off all the sulphuretted hydrogen, then filtered, eva-
d, and cooled till it crystallises.—2. By heating a mixture of 2 pts. heavy spar,
pt. fused chloride of calcium to redness for about an hour. Sulphate of calcium and
de of barium are then formed ($SO^4Ba'' + Ca''Cl^2 = Ba''Cl^2 + SO^4Ca''$), and the
may be extracted by pulverising the fused mass, boiling with water, and filter-
quickly as possible; otherwise, a portion of the chloride of barium will be re-
rted into sulphate, because the sulphate of calcium in the residue gradually
ves in the water, and mixing with the dissolved chloride of barium, produces a
on exactly the reverse of that which took place in the fused mass. The decom-
on of the sulphate may be facilitated by adding to the mixture in the crucible a
ity of iron filings and charcoal. Sulphide of iron is then formed, together with
oluble oxysulphide of calcium, from which the chloride of barium may be sepa-
by water as above.

nmercial chloride of barium often contains small quantities of the chlorides of
ium and calcium; also chloride of aluminium, sesquichloride of iron, and some-
traces of copper and lead. The chlorides of strontium and calcium may be
ed by washing the crystals with alcohol; the latter also by digesting the aqueous
on with carbonate of barium, whereby the chloride of calcium is slowly decom-
and converted into carbonate; the same decomposition may be more quickly
ed by adding baryta-water, and then passing carbonic acid gas into the liquid.
tion with carbonate of barium also precipitates the aluminium and iron in the
of sesquioxides. Lead and copper may be precipitated by adding to the solution
ll quantity of sulphide of barium.

loride of barium crystallises from its aqueous solution in transparent, colourless,
ided tables, belonging to the trimetric or right prismatic system. The form of
rystals resembles that of heavy spar. The angles are $\infty P : \infty P = 93° 20'$;
$\breve{P}\infty = 142° 35'$; $oP : \frac{1}{2}\breve{P}\infty = 140° 57'$. The crystals decrepitate in the fire.
specific gravity is 2·66 (**Filhol**); cubical expansion from 0° to 100° C. = 0·00987
le and **Playfair**). They have an unpleasant, bitter, and sharply saline taste,
nausea, and are highly poisonous.

pts. of water at 0° C. dissolve 32·62 pts. of anhydrous chloride of barium, and

0·2711 pts. for every degree above 0° C.; 100 pts. of water at 15·6 dissolvo 43·5, an
105·5°, 78 pts. of the crystallised chloride (Gay-Lussac). One pt. of crystall
chloride of barium dissolves at 18·1° in 2·257 pts. of water, forming a solutio
specific gravity 1·28251 (Karsten). Specific gravity of a saturated solutio
8° = 1·270 (Anthon). Water acidulated with hydrochloric acid dissolves less
pure water, and concentrated aqueous hydrochloric acid hardly any; so that a
rated solution in water is precipitated by it. Hot absolute alcohol dissolves
$\frac{1}{400}$ pt. of the crystals, but more if it contains water. According to Frese
(Ann. Ch. Pharm. lix. 117), one pt. of the salt dissolves in 8108 pts. of alcoho
99·3 per cent. at 14° C., and in 4857 pts. of the same alcohol at the boiling heat.

The crystals do not effloresce in the air: at 100° C. they give off the whole of
water, leaving the anhydrous chloride in the form of a white mass, which melts
full red heat, and is translucent after solidification. Specific gravity of the anhyd
chloride = 3·7037 (Karsten), 3·8 (Richter), 3·86 to 4·156 (Pol. Boullay). He
by itself, it does not become alkaline till after fusion; but when heated in aqu
vapour, it becomes alkaline below the melting point, and evolves hydrochloric
By ignition with sulphur it is partly changed into sulphide of barium (Karst
It is not decomposed, at ordinary temperatures, by vapour of anhydrous sulphuric
According to H. Wurtz, it completely decomposes silicates when fused with them.

Chloride of barium in the state of concentrated solution, is decomposed by nit
of potassium or sodium, yielding nitrate of barium and a chloride of the alkali-m
It forms a crystalline compound with glycocol. Blood mixed with it remains
and does not putrefy.

The chief use of chloride of barium is as a chemical reagent, especially for
detection and estimation of sulphuric acid.

BARIUM, CYANIDE OF. See CYANIDES.

BARIUM, DETECTION AND ESTIMATION OF. 1. *Reaction*
the dry way.—Barium-compounds, heated in the inner blowpipe flame, colour
outer flame green. They likewise impart a green colour to the flame of alcohol,
when this flame is examined with a prism by Bunsen and Kirchhoff's method
ANALYSIS, INORGANIC, p. 214, and LIGHT), a spectrum is seen, having several b
green bands, in the neighbourhood of Fraunhofer's lines *b*, *E*, a bright yellow
coincident with the line *D*, a bright orange band just beyond it, and two fa
orange-red bands, one of which nearly coincides with the line *C*.

Reactions in the wet way.—The hydrate, sulphide, chloride, nitrate, and
organic salts of barium, the acetate, for example, are soluble in water; most of
other salts are insoluble in water, but soluble in nitric and hydrochloric acid:
sulphate and the silicofluoride are insoluble in all acids. All barium-compounds
colourless, excepting those which, like the chromate, contain a coloured acid.
soluble salts of barium are poisonous. Solution of *potash* (free from carbonate), f
a precipitate of hydrate of barium, only in very concentrated solutions of barium-s
ammonia forms no precipitate, even in the most concentrated solutions. *Alkaline*
bonates form a white precipitate of carbonate of barium, soluble, with effervescenc
hydrochloric acid. *Phosphate*, *arsenate*, *borate*, and *iodate of sodium*, also form pre
tates soluble in acids. *Free oxalic acid*, or acid *oxalate of potassium*, precipit
oxalate of barium, only from very concentrated solutions; neutral alkaline oxa
form a precipitate in all neutral solutions of barium-salts, which are not very di
Neutral alkaline succinates precipitate barium-salts quickly or slowly, accordin
the concentration of the solutions. *Ferrocyanide of potassium* forms a precipitat
moderately dilute solutions; *ferricyanide* only in strong solutions. *Sulphydric*
sulphide of ammonium, and *perchloric acid*, form no precipitates. *Sulphuric acid*
soluble sulphates, throw down sulphate of barium, from all solutions of barium-
whether neutral or acid. The precipitate is insoluble in nitric or hydrochloric
even at the boiling heat. A solution of nitrate of barium, containing only
of baryta in 50,000 to 100,000 pts. of water, gives a very distinct cloudiness
sulphuric acid or sulphate of sodium; with 200,000 to 400,000 pts. of water,
some minutes only; and with 800,000 pts, of water, the reaction is no longer vis
(Lassaigne, J. Chim. méd. viii. 526.) According to Harting (J. pr. Chem.
58), a solution of chloride of barium containing 1 pt. of baryta in 71,000 pts. of w
becomes turbid with sulphate of sodium after the lapse of half an hour. Alk
chromates form with barium-salts, a yellowish precipitate of chromate of barium,
soluble in dilute acids, soluble only in a large excess of nitric acid. *Hydrofluo*
acid forms with barium-salts, after a while, a white crystalline precipitate, nearl
soluble in nitric or hydrochloric acid. This reaction will detect 1 pt. of the chlo
in 3800 pts. of water. The precipitation is accelerated by addition of alcohol.

This last reaction affords a complete distinction between barium and stronti atter metal not being precipitated by hydrofluosilicic acid. The reaction with uric acid distinguishes barium in solution from all other metals, except lead and tium. From lead it is easily distinguished by its behaviour with sulphuretted ogen, which forms a black precipitate with lead, and by many other characters. tium and calcium are distinguished from barium by the greater solubility of their ates, so that a solution of sulphate of strontium, or calcium, added to a soluble m-salt, forms a precipitate of sulphate of barium. Another distinction is afforded e colour imparted to the flame of alcohol by the compounds of these two metals, m-compounds colouring the flame pale green (p. 500), while strontium compounds r it deep red. The tabular crystals of chloride of barium, which are nearly in- le in alcohol, likewise afford a means of distinguishing barium from strontium calcium, the chlorides of which form hygroscopic needle-shaped crystals, easily le in alcohol.

Quantitative Estimation.—Barium is always estimated in the form of ate. The precipitation is effected by means of dilute sulphuric acid. The acid be added in excess, and to a hot solution of the barium-salt; otherwise a small tity of the original salt, especially if it be nitrate, will be thrown down undecom- l together with the sulphate. The precipitate is washed with hot water, ignited moderate heat, together with the filter, and the amount of barium or of baryta lated from its weight. 100 pts. of it correspond to 58·78 pts. of barium, and of baryta.

is mode of estimating barium is very exact; but the precipitate, unless certain utions are taken, is very troublesome to filter, sometimes passing through as a y liquid, and sometimes completely stopping up the pores of the paper. To avoid inconveniencies, the liquid must be heated, and the precipitate allowed to settle completely, before the filtration is commenced. The clear liquid is then to be ed through the filter, the precipitate stirred up with boiling water, and again left ttle down, this clear liquid also poured through the filter, and the same process ated three or four times. The result of this treatment is to render the precipitate e and granular; it may then be poured on the filter, and washed with hot water ove-mentioned.

ecent experiments have shown that sulphate of barium is soluble to a perceptible t in strong hydrochloric, and still more in nitric acid (Calvert, Chem. Gaz. , 55.—Nicholson and Price, Phil. Mag. [4] xi. 169.—Noad, Chem. Soc. Qu. . 25). According to Seigle (J. pr. Chem. lxix. 144), it is also slightly soluble ilute acids, but less in acetic than in hydrochloric or nitric acid. Care must fore be taken that the liquid, from which the sulphate of barium is precipitated, not contain too much free acid; and it must be washed with pure, not with lated water.

rium may also be estimated as carbonate; but the method is less accurate that just described, because carbonate of barium is not completely insoluble in r.

Atomic Weight of Barium.—The most exact estimations of this number have made by determining the amount of chloride of silver obtained by precipitating chloride of barium with nitrate of silver. In this manner Marignac (Ann. . Pharm. lxviii. 215), operating on chloride of barium purified by washing with ol, recrystallisation from water, and drying at a low red heat, found, as a mean x closely agreeing experiments, that 1 pt. of silver corresponds to 0·96365 pt. of l. Hence, the atomic weight of silver being 108, we have:

Atomic weight of $Ba'Cl$	= 0·96365 × 108	=	104·07
Whence deducting	. Cl . .	=	35·50
There remains .	. Ba . .	=	68·57

like manner the atomic weight of monatomic barium was estimated by Berzelius w. J. xx. 1014) at 68·40, and by Pelouze (Compt. rend. xx. 1047) at 68·65.

stly, Dumas (Ann. Ch. Phys. [3] lv. 129), by numerous experiments made with ide of barium, carefully purified and fused in a stream of hydrochloric acid gas, btained results varying between the limits 68·47 and 68·56; mean value = 68·5, r diatomic barium, Ba'' = 137.

e atomic weight of barium has likewise been estimated from the amount of ate produced from a given weight of chloride; but the results do not appear to trustworthy as those obtained by the method above described.

Separation of Barium from other metals.—The precipitation of barium ulphuric acid affords the means of separating it from all other elements excepting tium, calcium and lead. From *strontium* and *calcium* it may be separated by ofluosilicic acid, which throws down a crystalline precipitate of silicofluoride of

barium $Ba''F^2.SiF^4$. This precipitate is somewhat soluble in water, but the separa
may be rendered complete by adding alcohol and warming the liquid: from di
solutions it takes some time to settle down. It must be collected on a weighed fi
dried at a moderate heat, and weighed. 100 pts. of it correspond to 49·01 of bar
and 54·73 of baryta. For other methods of separation, see CALCIUM and STRONTI

The separation of *lead* from barium is easily effected by sulphydric acid, which
cipitates the lead as sulphide.

BARIUM, FLUORIDE OF. $Ba''F^2$.—Obtained by neutralising baryta-w
with hydrofluoric acid, by digesting the recently precipitated carbonate in that acid
by decomposing nitrate of barium with fluoride of potassium or sodium. It is a w
powder, or, when obtained by evaporating the acid solution, a granular crystal
crust. It is insoluble in water, but dissolves easily in nitric, hydrochloric, or hy
fluoric acid.

Fluoride of barium unites with the fluorides of boron and silicon, forming the c
pounds $Ba''F^2.2BF^3$ and $Ba''F^2.SiF^4$. The latter is nearly insoluble in water,
serves for the separation of barium from strontium and calcium, p. 502 (see B
FLUORIDES and SILICOFLUORIDES). It also forms a crystalline compound with chlo
of barium, $Ba''Cl^2.Ba''F^2$, which is produced on mixing a solution of fluoride of potass
or fluoride of sodium with chloride of barium. This compound is more soluble t
the fluoride itself, and remains as a granular mass when the solution is evaporated

BARIUM, IODIDE OF. $Ba''I^2$.—Formed when hydriodic acid gas is pas
over baryta at a red heat, the combination being attended with production of lig
Protosulphide of barium dissolved in water is mixed with a saturated alcoh
solution of iodine [iodine without the alcohol might be preferable], as long as a p
cipitate of sulphur is formed; the colourless filtrate is boiled rapidly—so as to prev
the action of the air—almost to dryness; the mass is dissolved in a small quantity
water, and filtered quickly; and the filtrate is evaporated to dryness in as shor
space of time as possible in a glass bolt-head. (O. Henry.)

On redissolving the mass in hot water and leaving the solution to cool, the hydra
salt crystallises in slender deliquescent needles containing, according to Croft (Ch
Gaz. 1856, p. 125), $Ba''I^2.7H^2O$; they dissolve readily in alcohol. Heated out
contact with the air, they leave the anhydrous salt, which is not decomposed by h
in a close vessel, but in contact with the air, decomposes slowly at ordinary tempe
tures and quickly when heated, giving off vapours of iodine and leaving baryta.

BARIUM, OXIDES OF. Barium forms two oxides, a protoxide, BaO, and
dioxide or peroxide, BaO^2; the first produced by the direct oxidation of the metal
by heating certain of its salts; the second, by heating the protoxide to dull rednes
contact with excess of oxygen.

PROTOXIDE OF BARIUM, or BARYTA, $Ba''O$, *Barytes*, *Terra ponderosa*, *T*
pésante, *Schwererde*.—Barium oxidises rapidly in the air, even at ordinary t
peratures, and when heated, burns with a dark-red light and is completely conver
into anhydrous baryta. This oxide is however more readily obtained by igniting
nitrate or carbonate of barium.

Preparation.—1. Nitrate of barium is heated in a porcelain crucible, or better i
porcelain retort, till it is completely decomposed, and no more red vapour or
oxygen is given off. The heat should be moderate at first, because the nitrate fu
and froths very much; but towards the end of the process, it must be raised to bri
redness. If the heat is too long continued, the baryta is apt to absorb carbonic a
and oxygen from the fire.

It is not convenient to use a platinum crucible in this process, because baryta atta
platinum rather strongly at high temperatures, and if a Cornish or Hessian cruci
be used, the baryta becomes contaminated with silica, alumina, oxide of iron,
other matters derived from the crucible. A porcelain vessel is attacked in the sa
manner, though less strongly, and the baryta prepared in it always contains sm
quantities of alumina and silica. This contamination. and likewise the inconvenie
arising from the frothing of the mass, may be obviated in some cases by mixing
nitrate with rather more than its own weight of pounded sulphate of barium (hea
spar). Such a mixture does not fuse, and may therefore be heated in an earth
crucible without attacking it (Mohr, Ann. Ch. Pharm. xxvii. 27). This process
very convenient when the baryta is to be used for purposes for which the presence
the sulphate is not objectionable, as for preparing baryta-water or the hydrate.

2. On the small scale, baryta may be conveniently prepared by igniting the iod
of barium, which readily gives up all its iodine and $\frac{5}{6}$ of its oxygen without fusion
frothing $I^2O^6Ba = BaO + I^2O^5$).—3. Carbonate of barium exposed to the strong
heat of a forge-fire is converted into baryta (Abich), and at an ordinary white he
when mixed with $\frac{1}{10}$ of its weight of lamp-black or charcoal, and made into a th

ith oil; the mixture should be heated in an earthen crucible lined with lamp-nd having a close-fitting cover. Baryta is prepared by this process on the large rom Witherite, to be used in separating crystallised sugar from molasses y and Dubrunfaut, Sill. Am. J. [2] xvi. 276). Baryta is also prepared on e scale by igniting a mixture of the carbonates of barium and calcium in a of aqueous vapour. (Jacquelain, Compt. rend. xxxii. 877.)

erties.—Greyish-white, friable mass, of specific gravity 4·7 (Karsten); *5·54.* l). It is strongly alkaline, caustic, and poisonous. It melts only at the st heat of a forge-fire, or in the flame of the oxyhydrogen blowpipe, forming a y slag. It is a non-conductor of electricity, but may be decomposed by the current, with the intervention of mercury, yielding barium and oxygen (p. 560). um deoxidises it at a red heat. Heated in vapour of sulphide of carbon, it forms te and sulphide of barium:

$$3Ba''O + CS^2 = CO^3Ba'' + 2Ba''S.$$

water it forms a hydrate (see below). It unites with alcohol and wood-orming the compounds $Ba^2O.2C^2H^6O$ and $Ba^2O.2CH^4O$. It dissolves readily e nitric and hydrochloric acid, and in some other acids; with many acids, insoluble salts. When vapour of sulphuric anhydride is passed over baryta, to low redness in a glass tube, combination takes place attended with incan-e, and sulphate of barium, SO^4Ba^2, is produced.

DE OF BARIUM and HYDROGEN; HYDRATE OF BARIUM, $Ba''H^2O^2$ or ^2O. *Hydrate of Baryta, Caustic Baryta, Hydrated oxide of Barium.*—Formed ction of water on anhydrous baryta ($Ba''O + H^2O = Ba''H^2O^2$). When anhy-aryta is sprinkled with water, the hydration takes place, with great evolution of d expansion of volume. Anhydrous baryta also rapidly absorbs water from the ne hydrate is usually prepared by heating a solution of sulphide of barium (ob-y igniting the native sulphate with coal or charcoal) with oxide of copper, till d portion of the liquid gives a white instead of a black precipitate with lead-Another mode of preparation is to decompose the nitrate of barium with soda. A solution of soda of specific gravity 1·10 to 1·15, whose strength has eviously determined, is mixed with an equivalent quantity of finely pounded of barium, the liquid being kept in a state of ebullition, and water being added ne to time in small portions to facilitate the solution of the nitrate; and when le is dissolved, the boiling liquid is rapidly filtered, if necessary, through a lter into a bottle which can be well closed. On cooling, it deposits an abundant crystals of the hydrate, which may be freed from the mother-liquor by draining, r by means of a centrifugal machine. The crystals retain but a very small y of nitrate, and may be freed from it by recrystallisation. Chloride of barium o be used in this preparation, instead of the nitrate, but the presence of small es of chloride of sodium in the product is more likely to be detrimental in the he baryta, than that of the nitrate. (Mohr, Arch. Pharm. [2] lxxxviii. 38.)

ate of barium crystallises from its aqueous solution in transparent, colourless, six sided prisms with four-sided summits. They contain 8 at. water: $Ba''H^2O^2$ dissolve in 20 pts. of water at 15° C. and in 2 pts. of boiling water. The solution, Baryta-water, has a strong alkaline reaction, is highly caustic, and absorbs carbonic acid from the air, forming a film of carbonate on the surface. rystals are efflorescent, and in vacuo over oil of vitriol give off ⅞ of their water allisation, leaving $Ba''H^2O^2.H^2O$. At 100° C. they melt, giving off 1 at. water, red heat the remainder of the water of crystallisation is given off, leaving hydrate $Ba''H^2O^2$ (Bloxam, Chem. Soc. Qu. J. xiii. 49). This, when heated not reduced to anhydrous baryta below a red heat, but when heated in a of carbonic anhydride it is easily converted into carbonate of barium, with ion of water:

$$Ba''H^2O^2 + CO^2 = CO^3Ba'' + H^2O.$$

in a current of air, it takes up oxygen and is converted into peroxide of also with elimination of water. (Boussingault.)

$$Ba''H^2O^2 + O = BaO^2 + H^2O.$$

ate of barium is extensively used as a chemical reagent, viz. for the estimation onic acid, for precipitating metallic oxides, and especially for separating mag-om the alkalis.

OXIDE OF BARIUM, BaO^2.—Produced by heating anhydrous baryta ate of barium to low redness in a current of pure oxygen, or of air free rbonic acid. Pure anhydrous baryta absorbs oxygen with facility; the hy-ss readily, because it melts at the temperature required for the absorption:

the absorption may however be rendered rapid by mixing the hydrate of barium
lime and magnesia in sufficient quantity to prevent fusion, and keeping the mass
porous state, so that the oxygen may penetrate it thoroughly. Peroxide of ba
may also be produced by sprinkling red-hot baryta with four times its weig
pounded chlorate of potassium in successive small portions. Chloride of potassiu
formed at the same time, and on washing out this salt with water, the pero
remains in the form of a hydrate.

Peroxide of barium is a grey powder, somewhat more fusible than anhydrous ba
At a strong red heat, it evolves oxygen and is converted into baryta, and when v
of water is passed over it at a red heat, it likewise gives up half its oxygen and is
verted into hydrate of barium. The absorption of oxygen by hydrate of barium
red heat, and its subsequent evolution when the resulting peroxide is heated
stream of aqueous vapour, has been proposed by (Boussingault, Ann. Ch.
[3] xxx. 5) as a means of extracting oxygen from the air by a continuous pr
Hydrate of barium mixed with lime and magnesia, as above described, is heated
porcelain tube through which a current of air previously freed from carbonic a
drawn by an aspirator: and as soon as the conversion of the hydrate into perox
complete, the current of air is stopped, the temperature is raised, and vapour of
is passed through the tube as long as oxygen continues to be given off. Anhy
baryta may also be used instead of the hydrate, being first converted into peroxi
above, and the peroxide then decomposed by heating it to bright redness wi
passing aqueous vapour over it: but the temperature required for this decompo
is much higher; and moreover if the baryta contains small quantities of silic
alumina, which is often the case, it cakes into a very hard mass after frequent exp
to a high temperature, and will then no longer absorb oxygen with facility.

Peroxide of barium is readily decomposed by carbon, phosphorus, sulphur
drogen, and the metals, at a red heat, and by sulphydric acid at ordinary tempera
Heated over a large spirit-lamp in a rapid current of carbonic oxide, it becomes
hot, and at the same time small white flames burst out from its surface, pro
arising from the evolution of oxygen from the still undecomposed peroxide. A si
but more brilliant appearance is presented when the peroxide is heated in sulph
anhydride (Wöhler, Ann. Ch. Pharm. lxxxviii. 125). In contact with strong sulp
acid, it gives off oxygen at ordinary temperatures or when gently heated. If the
perature of the mixture does not exceed 50° or 60° C., part of the oxygen is ev
in the form of ozone; but above 70° C., nothing but ordinary oxygen is evolved.

Peroxide of barium thrown into water diffuses itself through the liquid and fo
hydrate, probably containing $BaO^2.6H^2O$. The same hydrate is precipitated in
talline scales when peroxide of hydrogen is added to strong baryta-water;
slightly soluble in cold water, but decomposes at the boiling heat, yielding free o
and hydrate of barium.

Both the anhydrous peroxide and the hydrate dissolve in excess of water acidu
with hydrochloric acid, forming chloride of barium and peroxide of hydrogen, wi
evolution of oxygen: $BaO^2 + 2HCl = BaCl^2 + H^2O^2$. When the peroxide is
with acidulated water in presence of oxide of silver, peroxide of manganese, per
of lead, &c., oxygen is evolved, both from the peroxide of barium and from the
oxide, so that the peroxide of barium here acts as a reducing agent (see CHE
AFFINITY and PEROXIDE OF HYDROGEN). Oxide, chloride, sulphate, or carbona
silver, introduced into an acid solution of peroxide of barium, is partly reduc
metallic silver, the quantity thus reduced being, however, always less than that
is equivalent to half the oxygen in the peroxide of barium (BaO.O). The qu
reduced increases with the amount of silver-salt present, and diminishes as the
perature is higher. A small quantity of the silver-compound, or of any similar
stance, is capable of decomposing a large quantity of peroxide of barium. Iodi
the other hand, decomposes an exactly equivalent quantity: $BaO^2 + I^2 = BaI^2$
(Brodie, Phil. Trans. 1850, 759.)

BARIUM, OXYGEN-SALTS OF. The general characters and reaction
described at p. 502. For the special descriptions, see the several ACIDS.

BARIUM, OXYSULPHIDES OF. A solution of sulphide of barium in
ing water, left to stand in a close vessel, first deposits crystals of hydrate of ba
and the liquid decanted therefrom yields scaly crystals, whose composition is
expressed by the formula $Ba^7S^2O^4.58H^2O$, and afterwards granular crystals, cons
of $Ba^2SO.10H^2O$. A moderately concentrated solution of the sulphide deposits,
about two months, large transparent tabular crystals, having the form of a hexa
dodecahedron, with truncated summits, and containing $Ba^4S^3O.28H^2O$ or BaO.1
+ $3(BaS.6H^2O)$ (H. Rose). These oxysulphides are very easily decomposible,
resolved by hot water into hydrate and sulphydrate of barium, of which, pe
they are merely mixtures.

IUM, PHOSPHIDE OF. BaP^2?—When vapour of phosphorus is passed -hot baryta, a brownish-red mixture of phosphide and phosphate of barium is , commonly called *phosphuret of baryta*, the reaction perhaps taking place in ner represented by the equation:

$$8BaO + 12P = 5BaP^2 + P^2O^8Ba^3.$$

composed by water, forming a solution of hypophosphite of barium, and ff a mixture of spontaneously inflammable phosphoretted hydrogen gas and rogen.

IUM, SELENIDE OF. $Ba''Se$.—Produced by exposing selenite of barium heat in contact with hydrogen gas or finely divided charcoal (lamp-black). uble in water, but decomposes at the same time, like the monosulphide, yield-ate of barium, and a higher selenide of barium, the solution of which is de-d by acids, with evolution of selenhydric acid and precipitation of selenium.

IUM, SULPHIDES OF. The *protosulphide*, $Ba''S$, is obtained by sulphydric acid or vapour of sulphide of carbon over red-hot baryta. ducing pulverised sulphate of barium in a stream of hydrogen or carburetted n. Either of these processes yields a very pure product; but for preparation arger scale, the native sulphate of barium is heated to bright redness with ceous matter. If charcoal is used, it must be thoroughly well incorporated e heavy spar, otherwise the reduction will be imperfect, as no fusion takes The admixture of resin, oil, or starch is advantageous, to bind the mass toge-d produce partial fusion; but a much better method is to mix the powdered with about ¼ of its weight of bituminous coal, and heat the mixture in a to full redness for an hour; the tarry matter of the coal then penetrates nly into the mass, so that every particle of the sulphate comes well in contact e reducing matter.

nass thus obtained consists of sulphide of barium mixed with excess of car-us matter and undecomposed sulphate; the sulphide of barium may be ex-by treating the mass with a sufficient quantity of hot water, and crystallised. method is to ignite a mixture of 100 pts. heavy spar, 200 common salt, and harcoal powder in a reverberatory furnace, and extract the sulphide of barium ater. The use of the chloride of sodium is to promote fusion. (Kuczinski, ry of Patent Inventions, 1835, p. 151.)

sulphide of barium is a white mass, having a hepatic odour and alkaline taste, ly soluble in water. Exposed to the air, it absorbs water and carbonic acid, onverted into carbonate, with evolution of sulphuretted hydrogen. When n the air, it oxidises but slowly, but when heated to redness in an atmosphere us vapour, it is converted into sulphate of barium, with elimination of hydrogen. ide of barium dissolved in water is easily decomposed by boiling with *oxide of oxide of iron, &c.*, forming hydrate of barium and sulphide of copper, &c. *loric, nitric, carbonic acid, &c.* decompose it, eliminating sulphuretted hydrogen, ning chloride, nitrate, &c. of barium. *Chlorine, bromine* and *iodine* decompose formation of the corresponding salts and deposition of sulphur. Sulphide of is indeed the material most generally used for preparing the other compounds m.

xture of sulphide of barium with the sulphate, such as is obtained by igniting hate with an insufficient quantity of carbonaceous matter (gum-tragacanth well, because it forms a paste with the heavy spar), acquires by exposure to s rays the property of shining in the dark: it is called the *Bolognian phos-*

water, protosulphide of barium forms hydrate and sulphydrate of barium:

$$2Ba''S + 2H^2O = Ba''H^2O^2 + Ba''H^2S^2.$$

uantity thus decomposed varies with the quantity and temperature of the When crude sulphide of barium, prepared by igniting the sulphate with ceous matter, is treated nine times in succession with a quantity of cold ss than sufficient to dissolve the whole, the mass being digested for twenty-urs each time in a closed vessel, the first two solutions obtained are of a llow colour; yield a large quantity of sulphuretted hydrogen and a pre-of sulphur, when treated with hydrochloric acid; and form with chloride ganese, a flesh-coloured precipitate of sulphide of manganese mixed with free sulphuretted hydrogen being likewise evolved: hence these solutions contain rate of barium (BaH^2S^2) together with a polysulphide of barium. The third behaves like a solution of protosulphide of barium containing a slight excess huretted hydrogen. The fourth is of the same character, but contains a

slight excess of baryta. This excess goes on continually increasing in the fifth,
and seventh solutions: and the eighth and ninth behave like pure baryta-w
yielding with chloride of manganese a white precipitate of manganous oxide. I
crude sulphide is at once treated with a quantity of water sufficient to dissolv
whole of the sulphide, the solution exhibits the characters of the pure protosulp
it may however be a mixture of hydrate and sulphydrate of barium (see the
equation). A solution of sulphide of barium in not too large a quantity of w
kept for some years in a stoppered bottle, deposits, first crystals of hydrate of ba
then scales which are a mixture of crystallised hydrate of barium and the hyd
protosulphide ($Ba''S.3H^2O$), and afterwards double six-sided pyramids containin
same substances, but much richer in sulphide of barium. The mother-liquor
down in a retort, evolves a continuous current of sulphuretted hydrogen, and on co
deposits hydrated sulphide of barium in the form of a white powder, while sulph
barium and hydrogen remains in solution.

Hydrated Sulphide of Barium, $Ba'S.3H^2O$, is a white powder, which soon
yellow. When treated at once with a quantity of water sufficient to dissol
perfectly, it yields a solution which when mixed with a manganous salt, yields
cipitate of sulphide of manganese ($Mn'S$) without evolution of sulphuretted hydr
but a smaller quantity of water extracts sulphydrate of barium and leaves hydr
barium undissolved.

Sulphydrate of Barium, $Ba''H^2S^2$ or $Ba''S.H^2S$.—Baryta-water, or
sulphide of barium reduced to a paste with water, and warmed, is saturated
sulphydric acid, the solution evaporated apart from the air, and cooled, when cr
of baryta and yellow prisms are formed. The remaining liquid is either evap
in a confined space, when white opaque prisms are obtained, or mixed with al
filtered from the sulphur and hyposulphite of barium produced by air contain
the alcohol, and cooled down to −10° C.; in this way, colourless and transp
four-sided prisms are produced. Also when baryta or either of its hydrated
pounds is allowed to crystallise, together with sulphide of barium, from an aq
solution of protosulphide of barium, by evaporation in a retort and cooling, an
residual liquid (which is of a yellowish colour, from the air not being per
excluded) further evaporated and cooled, it solidifies to a crystalline mass of su
drate of barium (H. Rose). The crystals contain water, which they lose
heated, becoming white at the same time. When exposed to the air, they effl
and turn white, while hyposulphite and sulphate of barium are formed. In a
they lose their water of crystallisation without fusing, and then evolve sulph
acid as the temperature approaches redness, leaving dark yellow protosulphi
barium, which becomes white as it cools. An aqueous solution precipitates ch
of manganese, with escape of sulphydric acid gas (Berzelius, Pogg. Ann. vi. 441)
salt, when boiled, evolves sulphydric acid. With iodine, it forms iodide of bariu
free hydriodic acid, sulphur being set free. It is insoluble in alcohol. (H. Ros

Trisulphide of Barium, BaS^3, is said to be obtained, together with sulpha
igniting 8 pts. of baryta with 6 pts. of sulphur, 1·78 pts. of the sulphur volati
during the process. On treating the product with water, the trisulphide diss
and 2·8 pts. of sulphate of barium remain behind (Vauquelin). Whe
moistened trisulphide is heated to redness and vapour of water is passed over it
phuretted hydrogen is given off, and sulphate of barium is formed. (Gay-Luss

Pentasulphide of Barium, BaS^5, is obtained in solution, by boiling the
sulphide or the sulphydrate with sulphur (H. Rose); also, together with hyposul
of barium, by boiling baryta-water with sulphur. The solution is yellow,
alkaline and caustic; leaves a pale yellow amorphous mass when evaporated in
and is decomposed by exposure to the air, with deposition of sulphur and formati
hyposulphite of barium.

BARLEY. See CEREALS.

BARNHARDTITE. A sulphide of copper and iron, $2Cu^2S.Fe^2S^3$, conta
traces of silver, found in a mine in Barnhardt's Land, and other localities in
Carolina. Bronze-yellow, with metallic lustre, sometimes dull and opapue. Fr
conchoïdal; no cleavage. Specific gravity 4·521. Hardness = 3·5. Brittle. S
greyish-black, somewhat shining. Tarnishes in the air, especially in contact
moisture, acquiring a brown or rose-red colour. Before the blowpipe, it give
reactions of iron and copper. (Genth. J. pr. Chem. lxiv. 468.)

BAROCALCITE. Syn. with BARYTOCALCITE.

BAROLITE. Syn. with WITHERITE.

BAROMETER (βάρος weight and μέτρον measure). The barometer is an i loyed to measure the pressure or weight of the atmosphere. It consists essen- continuous body of liquid, generally mercury, from one part of the upper which all pressure is removed, while the atmosphere still presses upon the of the surface. It is a law of hydrostatics that, in a heavy fluid, the pressure nts in a horizontal plane must be uniform, in order that there may be equi- The surface of the mercury cannot, then, remain in one plane, as it does atmosphere presses equally on every part, but it must rise where protected atmosphere, until the pressure of the portion thus rising exactly balances ces the pressure of the atmosphere. Thus in *fig.* 92, the surface of mer- hich the atmosphere presses is at A, and the glass tube A B, having been emptied of air and every other fluid, the mercury has risen to B, so that the ular column of mercury A B exerts a pressure at the horizontal plane A, exactly he pressure of the atmosphere at A.

pposing mercury to be always of one specific gravity, the *length* of the c column will be exactly proportional to the *weight* or pressure of the atmo- d thus a length expressed in inches or parts of a metre becomes a convenient for a weight. It is well, however, to bear in mind the real pressures indi- ich are easily determined, as in the following example:—

72 inches = mean height of barometric column for noon at Greenwich.
68 = specific gravity of mercury at 60° F.
137 oz. avoirdupois = weight of one cubic foot of water at 62° F.

$\frac{72 \times 13{\cdot}568 \times 997{\cdot}137}{12 \times 12 \times 12} = 233{\cdot}879$ oz. = 14·617 lbs. the average atmo- essure for noon at Greenwich on every square superficial inch.

Barometer at	28 inches	Atmospheric pressure	13·70 pounds
,, ,,	29 ,,	,, ,,	14·19 ,,
,, ,,	30 ,,	,, ,,	14·68 ,,
,, ,,	31 ,,	,, ,,	15·17 ,,

any other liquid, is used, the height of the barometric column will be in- the specific gravity. Thus the height of a column of water corresponding inches of mercury at 60° F. is $29{\cdot}872 \times \frac{13{\cdot}568}{1{\cdot}000}$, or 405·3 inches or 33·77 feet; a column of sulphuric acid would stand $29{\cdot}872 \times \frac{13{\cdot}568}{1{\cdot}85}$, or 219 inches high.

ccount of a water barometer constructed for the Royal Society by Professor ill be found in Phil. Trans. cxxii. (1832), 539.

UCTION OF THE BAROMETER.—All that is necessary to construct a barometer is glass tube about three feet along at one end, to fill it perfectly with mercury, ng the finger over the open end, to invert the tube into a vessel of mercury. rawing the finger, the mercurial column descends a few inches, and a measure lied, the height of the column remaining is found. But to attain accuracy, cautions are required at every step.

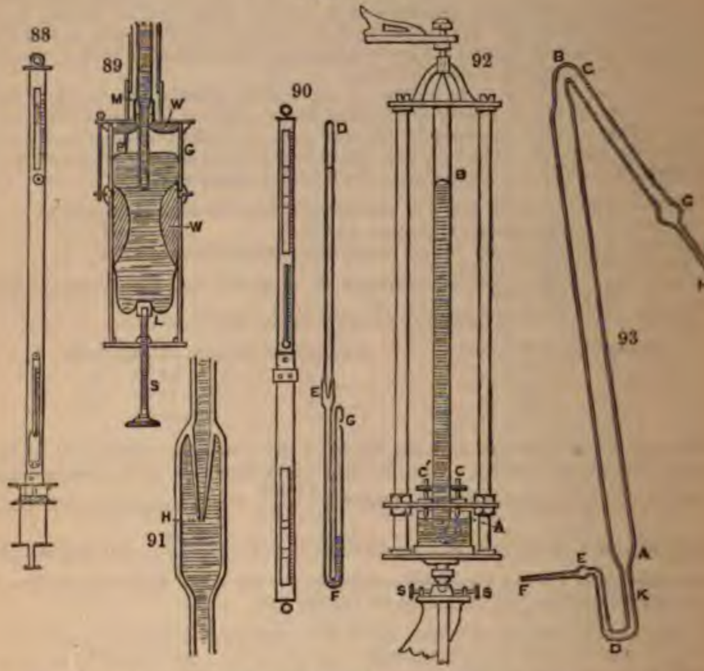
air remain in the tube, by adhering to the glass, it will rise into the space mercury, and its pressure, partly counteracting that of the atmosphere, will he barometric column. Most of the air may be got out by shaking the in the tube, but some will certainly remain, to eliminate which, the tube boiled as follows:—Fill only about six inches of the tube with mercury, and heat it over a strong flame or a charcoal fire until the mercury has boiled moments. At the same time, heat another portion of mercury, that it may the hot tube, and with it fill a few inches more of the tube. Expose this chiefly to the flame until it boils, and thus proceed, alternately pouring in a rcury and then boiling, until the tube is almost full. It would be well to e tube, if a large one, while cooling, to prevent fracture. When cold, fill it ith mercury, already boiled, and invert, with great precautions, to prevent of air. Any kind of dirt entering also will prove very detrimental, and the he first place, before sealing, should be thoroughly sponged out with whiting s of wine.

ercury used must be perfectly pure, otherwise it will be thick, sluggish, and well as somewhat false in specific gravity. To purify it, agitate with diluted d or sulphuric acid, and keep it under the acid, if possible, for a week or more, s washing with fresh acid and distilled water. Carefully distilled mercury ough, except that the dissolved oxide of mercury must be removed by treat- h sulphuretted hydrogen water, or dilute sulphide of ammonium.

forms of the barometer have been contrived since its first discovery by Torricelli; but, except in rendering the instrument portable and unalterable, no impr ment has ever, or perhaps can ever be made on the original simple form. In fact, most perfect barometer existing, the Great Standard at the Kew Observatory, r tioned further on, is also the most simple that could be imagined.

We shall, therefore, content ourselves with describing those forms of the barom which can be recommended to the observer of the present day for their accuracy convenience.

Figs. 88—93.



In *fig.* 88 is shown the **Portable Standard Barometer**, as first invented by F of Paris, and now made, amongst others, by Negretti and Zambra of Hatton Ga London, at a cost of eight guineas.

The barometer tube has an internal diameter of ·39 or ·40 inch, and the air is fectly driven out by the usual process of boiling. The cistern (*fig.* 89) is comp partly of a glass cylinder G, of boxwood sides and top, W and W', and of a leather b the bottom of which can be raised or lowered by the finger-screw, S. The whol of course, held together by a brass casing, and the barometer tube, the lower e which is contracted, is connected with the cistern by a leather joint at M.

To make an observation of this barometer, the lower surface of the mercury first be adjusted so as just to touch the ivory fiducial point P (*fig.* 89), by tur the screw S. The moment of exact contact may be very accurately observed, i mercury be properly clean and bright, by watching when the ivory point an reflection just meet; if the mercury be even $\frac{1}{1000}$ of an inch too low, light appear between the point and mercury; while, if too high, a small depres instantly detected by reflected light, will be caused in the mercurial surface b ivory point.

Next, the upper surface of the mercurial column is observed by adjusting the l edge of a moveable brass cylinder, so that it shall visually be the tangent to, th shall just touch, the curved surface of the mercury. To avoid the error of para the line of vision must be exactly horizontal. The scale of inches, with the assist of the vernier engraved on the moveable cylinder, then gives the actual height o column, subject to index error, within the $\frac{2}{1000}$ part of an inch. But the observer, a little practice, will soon discriminate the $\frac{1}{1000}$ part by the naked eye.

A Barometer should never be carried about in its ordinary upright position column, being delicately balanced against the weight of the air, will be ate, or as it is said, to *pump* rapidly up and down when the barometer rtical disturbance. Not only might bubbles of air adhering to the lower ube be thus carried up, but the mercury violently striking the sealed end, might shatter a tube that was not very strong. To render this rtable, the handscrew at S must be screwed up, and the instrument d at the same time, until the mercury fills the whole of the tube, and hole of the cistern; it is then to be inverted and kept or carried about as ible in this position until again safely suspended. A board and bracket, n the figures, accompany this barometer, as also an arrangement of by which it may be secured motionless in the vertical position, which it mes when free. Such a barometer is very suitable and quite good enough ry, or for a series of meteorological observations. It is the form of baro-steemed on the Continent.

AIN BAROMETERS, which require to be far more portable and secure from n that above described, the best is Gay-Lussac's form (see Ann. de , i. 113), as improved by Bunten, and drawn in *fig.* 90 from an instru-retti and Zambra. Its tube is in the form of a syphon, of which the F G have an uniform diameter of ·2 inch, while the part E F is a capil-h a bore of about ·05 inch. The end of the tube at G is sealed, but a omewhat sunken hole is pierced about an inch below the end, so that air ely in or out, but not the mercury. At E is a pipette or air trap, shown ale in *fig.* 91, contrived by Bunten, so that even if air pass up the tube llect at E, since it is scarcely possible that it should find its way through communication (H, *fig.* 91) into the upper part of the tube.

s loosely packed in a brass tube-case, through two slits in which the ver surface of the mercury may be observed in the same manner as the in the Fortin barometer. There are two divided scales, both 9 inches asured from the lowest point of the lower scale, and the difference of the he height of the barometric column. The verniers read to the $\frac{1}{1000}$ of

STANDARD BAROMETER is well known, and has long been relied upon in es as well as this. The tube has a diameter of ·5 or ·6 inch, and stands indrical glass cistern. The graduated scale is of brass, affixed to a brass lown the inside of one of the upright supports, and terminating below in ory point, which by an endless screw and wheel is very accurately ad-tact with the mercury. In this respect the construction is superior to Fortin barometer, because the mercury when raised or lowered, as in the ot at once assume its true position, owing to adhesion. Mr. Newman has ethod of filling his barometer-tubes in vacuo, and of boiling them under ressure, which obviates all oxidation and fouling of the tubes.

T STANDARD BAROMETER of the Kew Observatory, constructed by the sh, has a tube 1·1 inch in bore, and as it was found impossible to fill so satisfactorily in the ordinary way, the following excellent method was To the upper end of the barometer tube A B (*fig.* 93) was attached a e A D E F, much contracted at D, with a small bulb at E, drawn out at F int, and hermetically sealed. To the lower end of the large tube was inches of a smaller tube B C G, having a bore of 0·3 inch, and to that dded about 6 inches of capillary tube G H. A bulb of $\frac{3}{4}$ of an inch was and the small tube finally bent into a syphon form at B. The end H of tube was now connected with a good air-pump, and the air very slowly the same time that the whole tube was strongly heated by passing a ame along it. When the air had been as well as possible extracted, and ump was still in action and the heat still applied, the capillary tube G H t I by a blowpipe flame. When the tube had cooled, it was placed at a tion with the end F in perfectly pure mercury, which had been previously he point being broken off, the mercury rose until the bulb at G was more led. The point F was then again sealed, the capillary tube remaining vith mercury. When the glass at F had cooled, the whole tube was in-ercury now separating at the contracted part D, leaving the tube from D very nearly so, and from D to A perfectly vacuous. The operation was sealing the tube at K, removing the portion K D E F, placing the bend B of the barometer, and breaking off the tube C G at the point C.

finally adopted at Kew, is perfectly free from air in the portion B, which ong; it is mounted in an open brass frame (*fig.* 92), adjusted to verti-ws at S; at C C′ are two steel rods, the first terminating below in a conical ond in a knife-edge, and both adjusted so as just to touch the surface of the mercury in the cistern. The height of the mercurial column is then easily ob by a cathetometer placed five feet off, the telescopic wire of which is made alter to bisect a mark on the head of the rods c or c′, and to form a tangent to the me surface at B. The difference of the readings on the divided scale of the catheto added to the known length (3·515 for c) between the point and end of the ste and the mark on its head, gives the actual length of the barometric column. cistern of this barometer stands 33·9 feet above the mean sea-level. (Phil. [1856] p. 507.)

A very interesting account of the construction of the Royal Society's St barometer by Daniell, will be found in his Meteorological Essays, p. 353. S Mr. Baily's Description of a New Barometer, Phil. Trans. cxxvii. 431; and Hu Phil. Trans. [1832] p. 575.

We will now consider the precautions and corrections necessary in obtaining th atmospheric pressure with exactness.

Correction for Capacity.—It is obvious that in proportion as the bar stands higher, so much more mercury there must be in the tube, and conseque much less in the cistern. We should not then get the true variations in the le the mercurial column, by noticing the top of the column only, since the base column also varies, and a correction must obviously be made for the amount variation.

This correction, indeed, is not required in any of the barometers above des because observations or adjustments are made both at the upper and lower s of mercury. But in many other barometers, the scale is measured trul the lower surface of the mercury, only when the column is at one particular called the *neutral point*, usually determined by the barometer-maker, and mar the instrument. When the column is higher or lower than this point, the merc the cistern must be lower or higher in a proportion depending on the sectiona of the tube and cistern. If H be the height of the neutral point, and h the ob height of the barometer, the correction for capacity is

$$+\left\{\frac{\text{diameter of tube}}{\text{diameter of cistern}}\right\}^2(h-H)$$

In the marine barometer adopted by the Board of Trade, this correction is ac performed upon the divided scale, so that the inch divisions are about $\frac{1}{8}$ les real inches. In any syphon barometer, like that of Gay-Lussac, in which bot are of equal diameter, the correction for capacity is made by doubling the vari in height of one surface, and Gay-Lussac recommends this method when great is not required; but measurements of both surfaces are evidently necessa certainty.

Correction for Temperature.—The length of the barometric column is p tional to the pressure which it has to measure only so long as the specific gra mercury is constant. Now mercury expands $\frac{1}{10000}$ of its own volume whe temperature rises one degree (Fahr.), and its density of course varies inversely. all readings of the barometer must be reduced to what they would be at one u temperature, that of 32° Fahr., when the specific gravity becomes 13·60. The scale by which the height is measured also expands by heat, and is only of the sta length when at a temperature of 62° F. (for the English yard).

To ascertain the temperature of the barometer, a thermometer is always att This should be placed half way up the barometer tube, with the bulb close to the and well covered up from the atmosphere. The barometer should be placed room of which the temperature changes as little and as slowly as possible.

If h be the observed height of the barometer, and t its temperature in degrees the height reduced to 32° F. is

$$h-h\times\frac{\cdot0001001(t-32)-\cdot000010434(t-62)}{1+\cdot0001001(t-32)}$$

but it is quite exact enough to subtract (or *add* if t be less than 29° Fahr.) th lowing correction:

$$h\left\{(t-32)(\cdot0001)-(t-62)(\cdot00001)\right\}$$

The reader will observe that the *cubic*, not the linear, expansion of mercury is in these formulæ, for it is on the cubic expansion that the specific gravity depen

The correction is most conveniently obtained, however, from a table such a on the following page, which applies to barometers with *brass scales*, extending the cistern to the top of the mercurial column.

Table for the Temperature-correction of the Barometer.

29·0 inch.	29·5 inch.	30·0 inch.	30·5 inch.	Temp. °F.	28·5 inch.	29·0 inch.	29·5 inch.	30·0 inch.	30·5 inch.
·007	·007	·007	·007	61	·083	·084	·086	·087	·089
·009	·009	·009	·010	62	·085	·087	·088	·090	·091
·012	·012	·012	·012	63	·088	·089	·091	·093	·094
·014	·015	·015	·015	64	·090	·092	·094	·095	·097
·017	·017	·018	·018	65	·093	·095	·096	·098	·100
·020	·020	·020	·021	66	·096	·097	·099	·101	·102
·022	·022	·023	·023	67	·098	·100	·102	·103	·105
·025	·025	·026	·026	68	·101	·102	·104	·106	·108
·027	·028	·028	·029	69	·103	·105	·107	·109	·110
·030	·030	·031	·031	70	·106	·108	·109	·111	·113
·033	·033	·034	·034	71	·108	·110	·112	·114	·116
·036	·036	·036	·037	72	·111	·113	·115	·117	·119
·038	·038	·039	·040	73	·113	·115	·117	·119	·121
·040	·041	·042	·042	74	·116	·118	·120	·122	·124
·043	·044	·044	·045	75	·118	·120	·122	·125	·127
·045	·046	·047	·048	76	·121	·123	·125	·127	·129
·048	·049	·050	·051	77	·123	·126	·128	·130	·132
·051	·052	·052	·053	78	·126	·128	·130	·133	·135
·053	·054	·055	·056	79	·128	·131	·133	·135	·137
·056	·057	·058	·059	80	·131	·133	·136	·138	·140
·058	·059	·060	·061	81	·134	·136	·138	·141	·143
·061	·062	·063	·064	82	·136	·138	·141	·143	·146
·064	·065	·066	·067	83	·139	·141	·143	·146	·148
·066	·067	·068	·070	84	·141	·144	·146	·149	·151
·069	·070	·071	·072	85	·144	·146	·149	·151	·154
·071	·073	·074	·075	86	·146	·149	·151	·154	·156
·074	·075	·076	·078	87	·149	·151	·154	·157	·159
·077	·078	·079	·081	88	·151	·154	·157	·159	·162
·079	·080	·082	·083	89	·154	·156	·159	·162	·165
·082	·083	·085	·086	90	·156	·159	·162	·164	·167

ables, as originally calculated by Prof. Schumacher (Jahrbuch für 1837, ı. t. ii.), will be found in the "Report of the Committee of the Royal hysics," 1840. The Admiralty "Manual of Scientific Enquiry," and most ysics and Meteorology, also contain tables, often slightly differing from

an approximate correction, multiply the number of inches in the height of by the number of degrees Fahr. above 32°, and subtract ·0001 inch for f the result. The following data are useful.

	For 1° Fahr.	For 1° Centigrade.
ent of the cubic expansion of ry 001001 = 0·0000435)	·0001001	·00018018
nt of the linear expansion ss	·00000956	·00001722
nt of the linear expansion ss adopted by Schumacher	·0000105	·0000188
nt of the linear expansion ss.	·0000048	·0000086

ust be employed instead of the coefficient of brass, when the scale is the glass barometer tube, as often occurs on the Continent. Tables for scales and centigrade degrees, will be found in Bunsen's Gasometry, y Roscoe.

LARY DEPRESSION of the mercurial column is a formidable obstacle to the of accuracy when the tube is of small bore. For this reason, important ometers, like that of Kew, have a large tube in which the capillary de- appreciable.

of the depression is, that the particles of the mercury have a much action for each other than for the glass; a slight resultant attraction thus ng to draw each particle towards the general mass of mercury. The form urface of the mercury assumes is spheroïdal; the highest point of the be always taken, in adjusting the edge of the vernier for an observation. ny error from the capillary depression, it is far the best way to compare the ith an undoubted standard barometer in which the capillary depression is e. The correction for capillarity is then merged into that for index error.

If this be not done, the *bore* of the barometer tube must be ascertained fro barometer maker, or otherwise, and the correction then taken from the following t which is the one generally adopted for the purpose in England.

Diameter of tube.	Add to the reading for		Diameter of tube.	Add to the reading for	
	Unboiled tubes.	Boiled tubes.		Unboiled tubes.	Boiled tu
0·60 inch.	0·004 inch.	0.002 inch.	0·30 inch.	0·028 inch.	0·014 in
0·50 "	0·007 "	0·003 "	0·25 "	0·040 "	0·020
0·45 "	0·010 "	0·005 "	0·20 "	0·060 "	0·029
0·40 "	0·014 "	0·007 "	0·15 "	0·088 "	0·044
0·35 "	0·020 "	0·010 "	0·10 "	0·142 "	0·070

Continental observers have attempted to attain greater accuracy by making height of the meniscus or curved surface of the mercury an *argument* in the corre M. Delcros has calculated an elaborate table on this principle of which a part is given.

Bore of the tube. Millimetres.	Height of the meniscus in millimetres.								
	0·2	0·4	0·6	0·8	1·0	1·2	1·4	1·6	
3·0	0·24	0·48	0·70	0·90	1·07	1·20	1·32		
4·0	0·12	0·24	0·35	0·46	0·55	0·63	0·71	0·77	
5·0	0·07	0·13	0·19	0·25	0·30	0·35	0·40	0·44	
6·0	0·02	0·06	0·09	0·13	0·18	0·20	0·23	0·25	0
7·0	0·01	0·03	0·06	0·09	0·10	0·12	0·14	0·15	0

For the full tables and for a very elaborate description of the principal sta barometers on the continent, the determination of their mean differences, an errors to which barometers are subject, the reader should consult a paper by Br and **Martins** in Nouv. Mém. de l'Acad. Roy. de Bruxelles xiv. 31 (1841); see **Dove**, Repertorium der Physik, i. 37.

The capillary depression of the barometric column has been investigated m matically by Mr. **Ivory** in the Philosophical Magazine and Annals for 1828, v p. 1. [This reference is usually wrongly given to the Philosophical Transactions

This correction is considered unnecessary to the Gay-Lussac, or any other s barometer, in which the two surfaces of mercury are of equal extent, and the subject to equal capillary action. But we think that the adhesion of the merc the lower limb of the Gay-Lussac tube, being much increased by the presence and dust, is liable to cause inaccuracy unless carefully attended to.

The INDEX ERROR is properly the error in the length of brass rod or sca tending between the two surfaces of mercury. Such error may usually be consi uniform for all parts of the divided scale, which is accurately divided by a ma and the error probably arises, if at all, from the wrong adjustment of the ivory fi point.

But the index error, as usually determined by comparison with a standard baro comprises the capillary depression before mentioned, as well as any minute errors impurity in the mercury, from imperfect vacuum in the upper part of the tube, of the attached thermometer, and so on. Comparison with a standard, in short, s the final accuracy of the result, and no observer of the present day who desires considered trustworthy should use an uncompared barometer. The purchaser barometer for scientific purposes should insist on receiving with it an authentic ficate of its index error from comparison with the Greenwich, Kew, or Royal S Standard. The best barometer makers, Negretti and Zambra, Newman of B Street, or Barrow of Oxenden Street, the latter the maker to the British Meteorol Society, will readily procure such a certificate. Of course a fresh comparison is sary if the barometer be in any way disordered or suspected of being disordered.

To compare two barometers, they should be suspended side by side, and a sco simultaneous readings of each taken at intervals, if possible when the baro column is at various heights, and both rising and falling. The readings of each meter are to be fully and carefully corrected for temperature, according to it ched thermometer; the mean difference of all the readings, together with the known x error of the one barometer, is the index error of the other barometer.

rom the uniformity of the readings, the observer may judge either of his own skill or ne character of the instruments. With good instruments and a careful observer, the rences should be uniform within about $\frac{2}{100}$ of an inch, and the whole index error, t from capillary action, should not exceed $\frac{2}{100}$ or $\frac{3}{100}$; thus, in the comparison of writer's barometer by Mr. Glaisher at Greenwich, the differences of twenty read- vary from −0·009 to −0·020, with a mean error of −0·014, apart from the med capillary depression ·008 inch, making the whole correction +·022 inch.

reated according to the formulæ of the calculus of probabilities, the *probable error* his determination from the mean of twenty observations is rather less than ·0015 . Assuming the Greenwich standard to be absolutely correct, this probable error 0015 inch is the only source of error which would not be eliminated by a proper of the instrument, and in the taking of a number of observations, as is always the in meteorology.

is curious that a barometer maker, named Assier-Perricat, of Paris, as long ago as 2, practised and advocated the method of ensuring the accuracy of barometers by parison. (Assier-Perricat, Nouveau Traité sur l'Invention des Barometres, etc.)

is important to be able easily to detect the presence of any air which might by dent get into the upper part of the barometer tube, where it would falsify the reading minute direct pressure, and probably also by increasing the capillary action. There pens to be a ready and perfect test as follows:—Incline the barometer so that the cury may run up and strike the sealed end of the tube; if the sound be sharp and allic, repeat the experiment several times, each time more gently. If the least e of air be present, the sound will at last become soft and puffy; if, on the con-, the vacuum be perfect, the sound will always remain beautifully clear and nctly metallic.

air be thus detected, uncover and examine the end of the tube, to see how large bble remains when the barometer is laid flat. Also invert the instrument and tap s sharply as is safe, near the bubble, which may sometimes be thus dislodged and inated. We do not think that a minute quantity of air can sensibly affect the ing of the barometer for ordinary purposes, but if there be more, the instrument t certainly be disused until refilled by the maker. If important observations have made with a barometer containing air, they may be corrected, if the barometer be pared with a true one before its condition is altered. The simple difference of ings will be an approximate correction, but the exact correction is

$$\frac{e_1 e_2(h_2 - h_1)}{e_1(h - h_1) + e_2(h_2 - h)}$$

hich e_2 and e_3 are the errors of the readings h_1 and h_2 at different points of the , as determined by comparison, and h is the reading to be corrected.

we suppose a bubble of air of $\frac{1}{50}$ of an inch diameter at the atmospheric pressure ter the vacuous space of the Fortin barometer, described above, the depressing t on the mercurial column may, by a simple calculation, be shown not to exceed of an inch, apart, however, from any influence on the capillarity, a point probably uch greater importance than the direct effect.

DIRECTIONS FOR TAKING AN OBSERVATION OF THE BAROMETER.

Read and record the attached thermometer, making a correction for index error ecessary (see THERMOMETER).

Adjust the mercury below to exact contact with the fiducial point.

Slightly tap the tube near the upper end of the column, and adjust the edge of vernier to exact tangential contact, the line of vision being horizontal.

Record the reading and work out the correct height as soon as convenient after- ls, as shown in the following example, which comprises all the corrections ever ired:—

			Inches.
ched thermometer . .	58·3 F.	Barometer reading . .	29·964
. Neutral point . .	28·861	Correction for capacity .	+·033
Capacity . . .	$\frac{1}{25}$	" " capillarity	+·007
Diameter of the tube .	·4 inch		30·004
Index error to K. O. Standard (apart from capillarity) .	−·014 inch	" " temperature	−·080
		" " index error	−·014
		True height of the barometer	29·910

When many observations of one barometer have to be made, much labour will saved by combining all these corrections into a special table, one reference to wh furnishes the required correction. In important observations or comparisons, the justments and vernier readings should be made with a pocket lens.

It is much to be desired that the English should adopt the metre scale for the ba meter, which is used all over the Continent; but although this may at once be done chemical matters, it seems almost impossible at present in meteorology. For the e reduction of the barometer scale from millimetres into English inches and *vice ver* we give the following tables. Negretti's portable barometer may be had with b millimetre and inch scales attached.

Millimetres.	Inches.	Millimetres.	Inches.	Millimetres.	Inches.
700	27·560	751	29·567	762	30·000
705	27·756	752	29·607	763	30·040
710	27·953	753	29·646	764	30·079
715	28·150	754	29·685	765	30·119
720	28·347	755	29·725	766	30·158
725	28·544	756	29·764	767	30·197
730	28·741	757	29·804	768	30·237
735	28·938	758	29·843	769	30·276
740	29·134	759	29·882	770	30·315
745	29·331	760	29·922	771	30·355
750	29·528	761	29·961	772	30·384

1 millimetre = 0·03937 inch
0·1 „ = 0·00394 „
0·01 „ = 0·00039 „

1 inch = 25·39954 millimetres
0·1 „ = 2·53995 „
0·01 „ = 0·25400 „
0·001 „ = 0·02540 „

Uses of the Barometer.—The chemist requires to know the atmospheric pr sure when very accurate weighings are made of light bodies, in order that the weig of the air they displace may be allowed for. On this subject, see Bessel's formulæ the article Specific Gravity. Secondly, gases are usually weighed or measured, su ject to the atmospheric pressure, and vary *directly in density* and *inversely in volu* with the pressure. Hence the atmospheric pressure must always be observed at t moment, in order that the weight or measure may be reduced, by a simple calculation, what it would be at some standard pressure, which in England is 30·000 inches, a on the Continent 760 millimetres or 29·922 inches. Now $\frac{30\cdot000}{29\cdot922} \times 100 = 100\cdot2$ or 100 cubic inches of gas at the English standard pressure are equal to 100·261 cu inches at the French standard pressure. It happens, however, that the English ado 60° F. and the French 32° F., as the standard temperatures in these matters, a allowing for the expansion of mercury between these points, 29·922 inches beco 30·006. Hence the true equivalent volume on the continental standard for 100 cu inches of gas at 30·000 inch, 60° F., is $\frac{30\cdot000}{30\cdot006} \times 100 = 99\cdot98$ cubic inches, the diff ence being so trifling that it may almost always be neglected.

Determination of Altitudes.—Since the barometer measures the weight of t *superincumbent* air, the higher we rise in the atmosphere the lower the barometer mu stand. At the surface of the earth, the barometer changes nearly ·001 inch for eve foot in the change of altitude; but more exactly, the change of elevation correspon ing to ·001 inch of the barometer, is:—

At temperature of 30° . . . . . . 0·865 foot
„ „ „ 40° . . . . . . 0·883 „
„ „ „ 50° . . . . . . 0·900 „
„ „ „ 60° . . . . . . 0·918 „
„ „ „ 70° . . . . . . 0·936 „
„ „ „ 80° . . . . . . 0·954 „

The difference of level (= x feet) of two barometers may be calculated by the follo ing formula:

$$x = 60345\cdot7 \times \left\{ 1 + 0\cdot002837 \cos 2\,\text{lat.} \right\} \times \left\{ 1 + \frac{T + t}{900} \right\} \log \frac{B}{b}$$

ch B and b are the simultaneous corrected heights of the barometers at the
and lower stations, and T, t the numbers of degrees Fahr. above 32°, at which
ermometers stand. (Biot, Traité de Physique, i. 100.)
he height does not much exceed 3000 feet, the following more simple formula
e used:

$$x = 52494{\cdot}3 \times \frac{B-b}{B+b} \times \left\{ 1 + \frac{T+t}{900} \right\}$$

neteorological observations, it is necessary to know the height of the barometer
the mean sea level, and to reduce the average results to that level accordingly, in
hat they may be comparable with observations made at other places, and reduced
milar manner.

TEOROLOGY.—The chief use of the barometer is of course in meteorology, since
es of pressure in the atmosphere are the immediate cause of all winds. These
es are extremely complicated and interesting: for besides the irregular fluctua-
and extraordinary disturbances during storms, there is an average change, ac-
g to the season, and a semidiurnal oscillation, probably due to a kind of
pheric tide, caused by the expansion of the atmosphere, where it is heated by
n's rays (Phil. Mag. [4] xvii. 313). In keeping a register of the barometer, it
be observed every day at 9 A.M., the time of the daily maximum, and at 3 P.M.,
ne of daily minimum, or else at noon, when the pressure is near the mean.
nightly maximum is about 9 P.M., the nightly mininum about 4 A.M. Almost
climate, however, is characterised by special laws of barometric fluctuation.

ROID BAROMETER. (α, priv. νηρος, liquid).—The essential part of this beautiful
ment is a small round metal box, exhausted of air, and with a thin circularly
lid, which the weight of the atmosphere more or less tends to press in. A
icated system of levers, causes an index, revolving over a dial, to mark the
est movements of this metal lid. (Vidi, Compt. rend. xxiv. 275; Belville's
al of the Mercurial and Aneroid Barometers.)

RDON'S METALLIC BAROMETER also consists of a vacuous metal box, but it is in
rm of a flat tube bent almost into a circle. The two ends of the tube approach
ede as the atmospheric pressure increases or diminishes.

se metallic barometers are very sensitive and excellent as weather glasses, and
hould be carried at sea or on exploring expeditions as a last resource in case the
rial barometers, as often happens, become disordered. But they afford no inde-
nt measure of pressure, and are so much affected by variations of temperature as
unsuitable for scientific use. The writer, however, has used an aneroid baro-
with some success, and obtained an approximate correction for temperature by
warming the instrument on various occasions, and noting the average change
ding (= ·0065 inch per degree F.) thus caused. An adjusting screw will be
at the back of the aneroid barometer, by which its reading may be made to
at some one point and temperature with that of a mercurial barometer.
a description of Macworth's "Underground barometer," see *Ure's Dictionary
ts, Manufactures, and Mines*, i. 255.) W. S. J.

RRAS. The resinous incrustation in the wounds made in fir-trees.

RSOWITE. A silicate of calcium and aluminium found near the river Bar-
in the Ural, in compact white masses or fine-grained aggregations, having a
ct cleavage in one direction. The granular variety has a faint mother-of-pearl
: the compact variety is dull and translucent on the edges. Sp. gr. 2·740 to
Hardness 5·5 to 6·0. Before the blowpipe, it melts with difficulty to a tume-
lass on the edges: with borax, slowly and quietly to a transparent colourless
likewise with phosphorus-salt, with separation of silica, the glass becoming
cent on cooling if the proportion of the mineral is considerable. With an equal
t of carbonate of sodium, it melts to a tumefied glass, which with a larger
ity of soda, becomes snow-white and infusible. With solution of cobalt, it
es blue on ignition. The powder is easily decomposed by hydrochloric acid,
ng a thick jelly. According to Varrentrapp's analysis, it contains $3(2\mathrm{Ca}''\mathrm{O}.\mathrm{SiO}^2)$.
$\mathrm{O}^3.\mathrm{SiO}^2$), a small quantity of the lime being replaced by magnesia. (Handw.
em. 2$^{\text{te}}$ Aufl. ii. 679.)

RWOOD or **CAMWOOD.** A red dye-wood, the colouring matter of which
rs to be identical with santolin (Preisser und Girardin, Ann. Ch. Pharm. lii.
See also *Ure's Dictionary of Arts, Manufactures and Mines*, i. 255.)

RYTA. See BARIUM, OXIDES OF.

RYTES, BARYTINE, or **BAROSELENITE.** See HEAVY SPAR.

RYTIC FLUORSPAR. A mixture of about equal parts of sulphate of barium

and fluorspar, occurring on the slaty limestone of Derbyshire, where it forms a
about an inch thick.

BARYTO-CALCITE, $Ba''Ca''(CO^3)^2$ or $BaO.CO^3 + CaO.CO^2$; a mineral f
in Cumberland, of a slightly yellowish-brown tinge, translucent, with a waxy lu
and sp. gr. 3·66. It contains cavities which are lined with crystals having the for
oblique rhombic prisms. The external surface is coated with sulphate of bariu
(Brooke, Ann. Phil. N.S. viii. 114.)

The name baryto-calcite was also given by Thomson to a laminated mineral
taining 71·9 p. c. sulphate of barium and 28·1 sulphate of calcium, found bet
Leeds and Harrogate in Yorkshire; also by Johnston to Alstonite, which is of
same composition but different crystalline form.

BARYTO-CŒLESTIN. This name is given to two minerals, both consi
of sulphate of barium and sulphate of strontium (cœlestin), one occurring near K
town in Canada, the other in the Binnenthal in Switzerland. The Swiss mineral f
orthorhombic crystals, containing, according to Waltershausen (Pogg. Ann.
134) 87·8 p. c. sulphate of barium and 9·1 sulphate of strontium. The Cana
mineral occurs in crystalline masses containing, according to Thomson, $BaSr^2.$
Allied to this is a mineral from the chalk marl of Moen, containing 40 p. c. Sr
28·3 $BaSO^4$, 15·5 $CaSO^4$, 13·5 $CaCO^3$ and 2·5 water.

BARYTOPHYLLITE. Syn. with CHLORITOÏDE.

BASALT. A rock of volcanic origin, occurring in amorphous masses, colun
amygdaloïdal, and vesicular. Its colours are greyish-black, ash-grey, and raven-b
Massive, with dull lustre and granular structure. Fracture uneven or concho
Concretions columnar, globular, or tabular. It is opaque, yields to the knife, bu
not easily frangible. Streak light ash-grey. Sp. gr. 3. Melts into a black glass
recovers its granular structure by slow cooling. It is found in beds and vein
granite and mica slate, the old red sandstone, and coal formations. It is di
buted over the whole world, and is met with in great variety in Scotland.

The most remarkable variety of basalt is the columnar, which forms imm
masses, composed of columns thirty, forty, or more feet in height, and of enor
thickness; those at Fairhead are two hundred and fifty feet high. These const
some of the most astonishing scenes in nature, for the immensity and regulari
their parts. The coast of Antrim in Ireland, for the space of three miles in le
exhibits a very magnificent variety of columnar cliffs; and the Giant's Cause
consists of a point of that coast formed of similar columns, and projecting into the
upon a descent for several hundred feet. These columns are, for the most
hexagonal, and fit very accurately together; but most frequently do not ad
together, though water cannot penetrate between them. Another very remark
formation of columnar basalt is the island of Staffa on the west coast of Scotl
The most extensive mass of basalt yet observed is that discovered by Colonel S
in the Deccan, where it occupies a surface of many thousand square miles.

Basalt is not a mineral of definite constitution, but a mixture of several mine
generally of labradorite, augite, olivine, magnetic iron ore, and a zeolite. T
minerals may however be replaced by others, namely labradorite by other varieti
felspar, and augite by amphibole: the zeolitic portion also varies greatly in co
sition. Some of the constituents of basalt viz. the olivine, the magnetic iron ore
the zeolite are decomposible by hydrochloric or sulphuric acid; the rest for the
part resist the action of acids; but the analytical results obtained by this mod
treatment are not very definite, inasmuch as the action of the acid varies wit
strength, with the state of aggregation of the basalt, and with the nature of
individual minerals of which it is composed. The constituents of basalt, are s
(about 50 per cent.) alumina, protoxide of iron, lime, magnesia, potash, soda
water, the proportions of which differ considerably in the several varieties of ba
as shown by the numerous analyses which have been made of it.

Basalt when calcined and pulverised, is said to be a good substitute for pozzo
in the composition of mortar, giving it the property of hardening under water. V
bottles have likewise been manufactured with it, but there appears to be some ni
required in the management to ensure success. A mixture of 1 pt. basalt, 2
broken glass, 2 soda, 1 wood-ash, and $\frac{1}{30}$ peroxide of manganese, has also been
for similar purposes.

BASALTIC HORNBLENDE usually occurs in opaque six-sided crystals, w
sometimes act on the magnetic needle. It is imbedded in basalt or grauwa
Colour velvet-black. Lustre vitreous. Scratches glass. Melts with difficulty to a b
glass. Contains 47 per cent. silica, 26 alumina, 8 lime, 2 magnesia, 15 iron, and

r. It is found in the basalt of Arthur's Seat, in that of Fifeshire, and in the Isles Iull, Canna, Eigg, and Skye; also in the basaltic and floetz traps of England, and, Saxony, Bohemia, Silesia, Bavaria, Hungary, Spain, Italy, and France. U.

ASANITE. See JASPER. — **BASANOMELANE.** See ILMENITE.

ASE. This term is the correlative of ACID, and denotes the electropositive constit of a salt. Its signification varies, however, to a certain extent, according to the which is taken of the constitution of salts. In the dualistic system, which rels salts as formed by the union of two binary compounds of the first order, *e.g.* hate of copper = $CuO.SO^3$; sulpharsenate of potassium = $3K^2S.As^2S^5$: hydrorate of ammonia = $NH^3.HCl$; nitrate of ethylamine = $NH^2(C^2H^5).HNO^3$, &c.; base is the electropositive oxide, sulphide, selenide, or alkaloïd, which unites with electronegative oxide, sulphide, &c., or hydracid; but in the unitary system, in ch the salts of any acid are regarded as formed on the same type as the acid (or rogen-salt) itself, the base must be understood as the metal or other electropositive cle by which the hydrogen of the acid is replaced: thus in the salts above-mened, regarded as $CuSO^4$, K^3AsS^4, NH^4Cl, $NH^3(C^2H^5).NO^3$, the bases are the radicles K, NH^4, $NH^3(C^2H^5)$. (See ALKALIS, ALKALOIDS, AMINES, AMMONIUM-BASES, DES, RADICLES.)

ASICERINE. See HYDROCERITE.

ASICITY. The power of an acid to unite with one or more atoms of base. See DS, p. 46.

ASILICUM, OIL OF. The leaves of the *Ocymum basilicum*, a plant belongto the labiate order, yield by distillation with water, an essential oil, which after hile deposits prismatic crystals, having the character and composition of hydrate urpentine, $C^{10}H^{22}O^3 = C^{10}H^{16}.3H^2O$ (Dumas and Péligot). The oil itself has not examined.

ASSIA LATIFOLIA. The seeds of this plant, which grows on the Himas, yield by pressure a yellowish oil, which gradually becomes colourless on expo to light, has a faint odour, a density of 0·958, and a buttery consistence at nary temperatures; melts at 27° to 30° C.; dissolves sparingly in anhydrous hol, scarcely at all in spirit of ordinary strength, readily in ether. By saponifica it yields, besides oleic acid and glycerin, two fatty acids, one which has not been ined pure, but appears to have the composition $C^{15}H^{30}O^2$; the other, originally posed to be a peculiar acid, and called *bassic acid*, is identical in composition and perties with stearic acid, $C^{18}H^{36}O^2$. (Hardwicke, Chem. Soc. Qu. J. ii. 231.)

ASSORIN. The principal constituent of *Gummi bassora*, *G. Toritonense*, or *Kutera*, a gum obtained from various species of acacia. This gum contains only t 5·6 per cent. of matter soluble in water (arabin), while the larger proportion, ch is the bassorin, merely swells up in water. (See GUM.)

ASTARD CLOVER. *Trifolium hybridum.*—100 pts. of the fresh flowering t yield 2·44 pts. of ash; 100 pts. of the dry plant 8·1 pts. of ash. The ash cons in 100 pts. 19·9 potash, 5·7 soda, 18·4 lime, 3·1 magnesia, 5·6 alumina (?), 3·9 uioxide of iron, 1·8 protoxide of manganese (?), 35·1 silica, 1·4 sulphuric anhydride, phosphoric anhydride, 0·6 chlorine. (Sprengel, J. pr. Chem. x. 56.)

ASTITE. A mineral found at Basti in the Harz, and forming imperfectly ned individual crystals intergrown with serpentine. It cleaves very easily in one ction, less easily in another, making an angle of 87° with the first; there are also imperfect cleavage-planes in the direction of the longitudinal and lateral faces. cture, uneven and splintery. Colour, leek to olive green, passing into yellow and wn. It has a metallic, glittering, nacreous lustre on the cleavage-faces; translucent he edges. Specific gravity 2·6 to 2·8. Hardness 3·5 to 4·0. Gives off water when ted, and before the blowpipe becomes pinchbeck-brown and magnetic; it then nters, melting to a brown glass on the edges. With borax and phosphorus-salt, gives the reactions of iron and chromium, and with the latter a skeleton of silica. s imperfectly decomposed by hydrochloric, completely by sulphuric acid. Its position is nearly represented by the formula $4MgH^4O^3 . 3(Mg^2 \text{ or } Fe^2)Si^3O^8$, ch, if the hydrogen be regarded as basic, may be reduced to the general form Si^9O^{36}, that is to say to the formula of an orthosilicate M^4SiO^4. Hermann rds the mineral as crystallised serpentine somewhat altered in composition by adture of foreign minerals; but its form indicates rather a relation to the augite ily. (Handw. d. Chem. i. 756.)

ASYL. Graham's name for the metal or other electropositive constituent of a (Elements of Chemistry, 2nd ed. i. 186).

BATATAS EDULIS. Sometimes called *Convolvulus batatas* or *Spa potato*, a plant said to be indigenous in India, but extensively cultivated in Ame and sometimes also in the south of Europe. The tubers resemble those of the po but have a sweeter taste. According to T. J. Herapath (Chem. Soc. Qu. J. 194), they contain, in the fresh state, 66·7 per cent. water and other volatile ma 31·8 vegetable matter, and 1·5 inorganic matter. The ash contains in 100 pts.: –

(*a.*) *Soluble in water.* — 8·7 CO^2, 7·1 SO^3, 0·9 P^2O^5, 29·3 K^2O, 12·4 KCl, and NaCl.

(*b.*) *Insoluble.*—6·2 CO^2, 7·1 P^2O^5, 12·0 CaO, 1·4 MgO, 1·3 Fe^2O^3, 2·1 SiO^2, traces of sulphuric acid and alumina.

According to Henry (J. Pharm. xi. 223) the tubers contain in 100 pts. 13·3 st 0·9 albumin, 3·3 sugar, 1·1 fat insoluble in ether, 6·8 woody fibre, 1·4 malic acid, phosphates, chloride of potassium, &c., and 73·1 water, also 0·05 of a volatile poiso matter.

BATH. The heat communicated from lamps and fires is subject to variation f many circumstances; and this variation not only influences the results of operati but often endangers the vessels, especially if they are made of glass. To obviate t sudden changes of temperature, and at the same time to afford means of observing regulating the degree of heat imparted, the vessel containing the substance oper upon is immersed in another containing water, oil, fusible metal, air, or other medi which receives the heat directly from the source. The sand-bath and water-bath most commonly used, the latter for maintaining a substance for any length of tim the constant temperature of 100° C., the former for higher temperatures, particul when the exact observation of the temperature is not an object. In using the wa bath, the vessel to be heated may, according to convenience, be either immersed the water or so placed above the vessel that its lower surface may be in contact v the steam. A ready method of constructing a water-bath for small operations i place the basin containing the substance to be heated on the top of another of e size, containing water and supported over a gas lamp.

The temperature of the water-bath may be raised above 100° C., by dissolving cer salts in the water. A saturated solution of common salt boils at a temperature of 7° or 13°·3 F., above the boiling point of water; and by using a solution of chloride calcium, a bath of any temperature between 100° and 125° C. or 212° and 252 may be conveniently obtained.

Liquid baths of higher temperature are obtained by the use of linseed oil or fu metal heated in cast-iron pots. The oil-bath may be used for temperatures up to a 300° C., but it is dirty, and exhales an extremely unpleasant odour when strongly hea Fusible metal is much cleaner and more pleasant to use, but its weight is an in

Fig. 94.

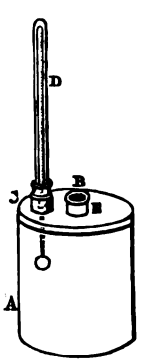
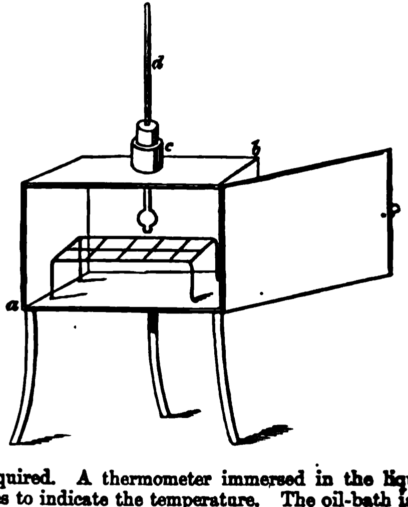


Fig. 95.



venience where a large bath is required. A thermometer immersed in the liquid near the middle as possible, serves to indicate the temperature. The oil-bath is m used in the determination of vapour-densities by Dumas's method, also for heat volatile substances or mixtures in sealed tubes, so as to subject them to a higher t

than that to which they could be exposed under the ordinary atmospheric
The danger of explosion attending this operation may be obviated by
; the sealed glass tube in a strong tube of wrought iron, having a massive
p.

r-bath is very convenient for many purposes, especially for desiccation. An
may be extemporaneously constructed by placing an empty basin over a lamp,
her basin containing the substance to be dried on the top of it. The upper
then heated by the air in the intervening space. A more convenient apparatus,
so serves to indicate the temperature, consists of a cylindrical copper vessel A,
ne cover of which is movable and has two apertures, the middle serving for
e of vapour and the lateral one for the insertion of the thermometer. The
be heated rests on a ring within the box, supported by a tripod. A larger
serving to heat several small vessels at once is represented in *fig.* 95. Air-
sometimes surrounded with a jacket to hold water or oil. When water is
temperature of course cannot exceed 100° C. When oil is used, the tempera-
dicated by a thermometer having its bulb immersed in the liquid.

ressure baths.—The danger of explosion in heating volatile liquids in sealed
greatly diminished, when the tubes are at the same time subjected to a pres-
without. This may be effected by enclosing the tube containing the volatile
a wider glass tube containing a less volatile liquid, and likewise sealed; the
then heated in an oil- or air-bath. In this manner, alcohol or ether may be

Fig. 96.

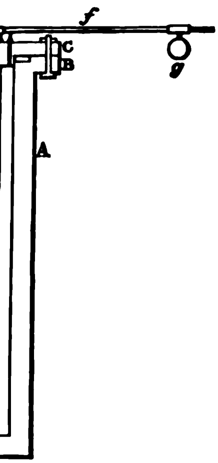
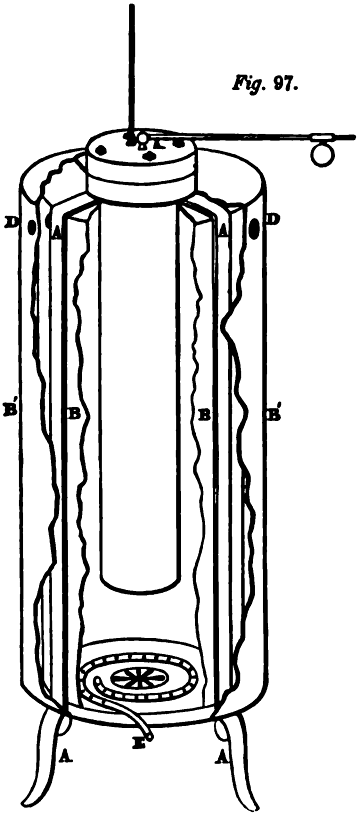


Fig. 97.



360° C., the outer tube containing oil of turpentine (**Berthelot**). Greater
is obtained by enclosing the glass tube in a wrought iron tube, with a
p, or by the use of a Papin's digester, or better, by the following apparatus
by **Frankland** (Ann. Ch. Pharm. xcv. 30).

(*fig.* 96) is an iron cylinder 18¼ inches long, 3 inches internal diameter,
ick in the side, and welded in one piece by the steam hammer. This cylinder

has a flanch, B B, $1\frac{3}{8}$ inch broad, $\frac{5}{8}$ inch thick, turned true on the upper surface having an internal annulus sunk $\frac{1}{20}$th of an inch below the level of the surrounding face. The cap C C, which is of the same diameter and thickness as the flanch, projecting face $\frac{1}{4}$ inch deep which fits exactly into the mouth of the cylinder. Withi projection the cap is pierced with two apertures, into one of which is fitted a cast-iro *d*, 6 inches long and $\frac{1}{2}$ inch in external diameter, filled with mercury and destin receive a thermometer. The other aperture is bouched with brass, and serves bed of the safety-valve, which consists of brass wire $\frac{1}{4}$ inch thick, somewhat flatten two sides, and furnished with a head accurately ground to the surface of the cap. valve is loaded in the usual way with a lever *f* and weight *g*. The cap and are fastened together by four screw-bolts, which are inserted from below and tigh by a lever-key, and the pressure thus exerted acts upon a lead washer $\frac{1}{8}$ inch placed in the annular depression of the flanch. In this manner the apparatus m made capable of bearing a pressure of 100 atmospheres without allowing any of gas. The cylinder A is about two-thirds filled with water, and the glass tube taining the volatile liquid is enclosed in it. In this manner, tubes of considerable may be heated without danger of explosion.

The apparatus is heated in a gas-furnace (*fig.* 97). A A A A is a massive fra wrought-iron, within which is fixed a cylinder B B, cf tin plate, closed at bottom open at top to receive the apparatus above described. *c* is a regulator for the sion of air. The gas-burner is a copper tube *e*, $\frac{1}{4}$ inch wide and pierced with 20 apertures. To prevent loss of heat by radiation, the whole apparatus is en in a cylinder B′ B′, of polished tin plate, separated from the inner cylinder by a about $\frac{1}{2}$ an inch wide. The products of combustion escape by the apertures D D

BATH-METAL. An alloy of copper and zinc containing a larger prop of zinc than ordinary brass, and usually prepared by melting brass with zinc.

BATRACHITE. A mineral found on the Rizomberg in the Tyrol, generally ma with a granular structure, rarely crystalline. It contains according to C. Ram berg (Pogg. Ann. li. 466), 37·69 silica, 35·45 lime, 21·79 magnesia, 2·99 protox iron. and 1·27 water. Colour varying from light greenish-grey, like that of (βάτραχος), to white; translucent with waxy lustre. Specific gravity 3·0 t Hardness = 5·0. Melts before the blowpipe, assuming a pale red colour with so of cobalt; is but slightly attacked by acids. The water appears to be unes and the composition of the mineral approaches to that of Monticellite. (Handw. d. ii. 757.)

BATRACHOLEIC ACID. An acid said to be contained, together with acid, glycerin, and a peculiar yellow fat, in the oil obtained by pressure fro epiploon of the water salamander. (Rossignon, Compt. rend. xiii. 929.)

BAUDISSERITE. A dense variety of magnesite containing silica, found Baudissero in Piedmont. As the amount of water contained in it is very var F. v. Kobell and Neumann regard it as a compact hydromagnesite intimately with silica.

BAULITE, or *Krablite.*—A mineral found on the Krabla in Iceland, and lik on the Baulaberg, either in short prismatic crystals belonging to the triclinic or d oblique prismatic system, or in crystallo-granular masses. Cleavage in two dire at right angles to each other. Fracture uneven and conchoïdal. Colourless, glassy lustre; transparent or translucent. Specific gravity 2·5 to 2·7. Hardne to 6·0. In the following table, *a* is the analysis of a specimen of baulite resem pearlstone, from the Baulaberg, by Forchammer (Ann. Min. viii. 644); *b* is t a crystallo-granular variety of baulite, ejected by the volcano of Viti in Iceland, with quartz-crystals and a black needle-shaped mineral, also by Forchhammer zelius's Jahresb. xxiii. 261): *c* is Genth's analysis (J. pr. Chem. lxvi. 93), of cr lised baulite from the Krabla:

	SiO^2	Al^2O^3	Fe^2O^3	FeO	Mn^2O^3	CaO	MgO	K^2O	Na^2O	Cl,	H
a.	74·38	13·78	1·94		1·19	0·85	0·58	2·63	3·57	0·12	2·
b.	76·65	11·57		0·63		0·05	0·20	3·26	3·73		
c.	80·23	11·34			trace	1·46	trace	4·92	2·26		

These analyses agree sufficiently well with the formula $(M^2O.3SiO^2).(Al^2O^3.6S$ which (if $al'' = \frac{2}{3}Al$) may be reduced to $(M'al^3)Si^9O^{22}$ or $2R^4SiO^4.7SiO^2$, the for of an orthosilicate with $\frac{7}{2}$ at. silica; but it is probable, as Bunsen supposes, tha mineral is intimately mixed with orthoclase. Before the blowpipe, baulite is fu in very thin splinters; with borax and phosphorus-salt it yields clear glasses, a sk of silica floating in the latter. It is insoluble in hydrochloric acid. (Handw. d. C ii. 758.)

LITE. See Baralite.

ALT. See Sodium, Chloride of.

IUM. A gum-resin of which there are two varieties, *African* and *Indian*. llium is derived, according to Perrotet, from a shrub indigenous in Sene- *Hendelotia africana* (Guillem and Perr); *Balsamodendron africanum* *Amyris Nicattout* (Adanson), belonging to the amyredaceous order. It lar, translucent masses, of a yellowish, reddish, or brownish colour, accord- unctuous to the touch, brittle, but soon softening, and growing tough fingers. Specific gravity 1·371. It has a bitterish taste, and a moderately mic odour, not unlike that of myrrh. It does not easily take fire, and fire soon goes out: in burning it gives off a balsamic odour, and sputters ng to the presence of moisture. Alcohol dissolves about ⅘ of it, forming a w tincture, from which water throws down a yellowish-white resin, and sulphur-yellow resin. Potash dissolves it completely. By dry distillation monia, together with other products. According to Pelletier (Ann. Ch. xx. 38), it contains 59 per cent. resin, 9·2 gum, 30·6 vegetable mucus, and oils (and loss).

is transparent, but becomes white and opaque by boiling with water; en 58° and 60° C. According to Johnston (J. pr. Chem. xxvi. 145), it is The gum is yellowish-grey, and when treated with nitric acid, yields malic c acid. The vegetable mucus is also yellowish-grey, swells up with water, ith alcohol, and is converted by nitric acid into a thin liquid. The volatile r than water.

dellium is said to be obtained from *Balsamodendron Mukal* (Hooker), redaceous tree, growing in Scinde. It forms irregular, greenish-brown, or sses, having a strong odour, and sharp bitter taste like myrrh. It becomes een the fingers.

Two species of bean are commonly cultivated in Europe, viz. 1. *Faba* *Vicia Faba*, the common field or garden bean (*Feldbohne*, *grosse Bohne*, the most common garden varieties of which are the Windsor broad bean, the long-pod, and the Mazagan, while for field cultivation, the Heligoland, n, and the common horse-bean, are preferred as being more hardy.— *s vulgaris*, the French, haricot, or kidney-bean, innumerable varieties of cultivated, some dwarf, others climbing. The scarlet-runner, *Phaseolus* is closely allied to this species.

s of these several species and varieties differ but little in chemical com- the following tables will show; but they are all remarkable for the large itrogenous matter (legumin) and phosphoric acid which they contain.

Table A.—*Composition in* 100 *parts of various kinds of Bean.*

	Legumin, &c.	Sugar.	Gum.	Starch.	Fat.	Pectin substances.	Woody fibre.	Ash.	Water.
(*air-dried*)	24·2	—	44·2		1·4	—	12·6	3·6	14·0
„	23·3	2·0	4·5	36·0	2·0	4·0	10·0	3·6	14·8
n	25·0	0·3	4·0	38·0	3·0	12·0		3·7	14·0
h (*undried*)	24·7	4·6		36·4	2·4	17·6*		1·8	12·8
un (*undried*)	24·6	6·5		31·5	2·8	18·8			10·8
n white (*air-*)	22·8	45·4			2·7	6·2†		1·8 3·6	19·3

iale (J. Pharm. [3] xxx. 180). The shells amounted to 15 per cent. of of the entire pods, and contained neither legumin nor starch.—2. Mean of yses by Braconnot, Horsford, and Krocker.—3. Mean of earlier analyses by oussingault, Horsford, and Krocker. 4, 5. Polson (Chem. Gaz. 1855. . Poggiale (*loc. cit.*) The shells amounted to 7·5 per cent. of the weight ire pods, contained very little starch, 0·2 per cent. fat, 6·5 nitrogenous l 5·8 ash.

nd Eggar (Jahresber. f. Chem. 1849, p. 708), obtained from several fresh beans grown on various soils: 2·4 to 3·6 per cent. nitrogen, 1·2 to t. fat, and 11·0 to 17·0 per cent. water.—Way and Ogston obtained from varieties of bean (Heligoland and Mazagan), grown on various soils, in the fresh seeds: 8·1 to 17·0 per cent. water, and in 1000 pts. of the dried ve varieties, 2·5 to 2·9 per cent. sulphur, in a sixth kind, 4·6 per cent.

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* Cellulose and Shells.

† Cellulose.

Mayer (Ann. Ch. Pharm. ci. 144), obtained from 100 pts. of air-dried M
beans, 11·8 to 12·5 per cent. water, 1·13 and 1·18 phosphoric anhydride, and
4·3 nitrogen. In dwarf haricot beans, he found 10·1 per cent. water, 1·06 pho
anhydride, and 3·32 nitrogen; in climbing haricot beans, 9·4 per cent. wate
phosphoric anhydride, and 3·17 nitrogen.

The sugar occurring in beans is usually regarded as grape-sugar. **Vohl** (A

TABLE B.—*Composition* (in 100

	Potash, K^2O.	Soda, Na^2O.	Lime, CaO.	M
I. SEED.				
Faba vulgaris.				
1. Common field bean from Holland . . .	20·8	17·8	7·3	
2. " " " Alsace	46·3	—	5·3	
3. " " " Giessen . . .	33·9	13·0	4·9	
4. " " " England . . .	51·7	0·5	5·2	
5. Mazagan bean (seed sown)	36·7	0·1	12·1	
6. raised therefrom on clay soil . . .	43·4	1·3	5·8	
7. " " sandy soil . . .	45·7	—	13·3	
8. Heligoland bean (seed sown).	42·9	1·6	7·7	
9. raised therefrom on clay soil . . .	43·5	2·4	4·8	
10. " " sandy soil . . .	40·7	—	8·2	
Phaseolus vulgaris.				
11. Haricot bean from Worms	38·9	11·3	5·9	
12. " " Alsace	51·0	—	6·0	
13. " " Kurhessen	22·1	21·4	5·5	
14. " " England	36·8	18·4	7·7	
II. STRAW.				
15. Common field bean	15·3	13·3	39·3	
16. " "	32·8	2·8	19·8	
17. Mazagan bean on clay soil	18·7	13·9	18·9	
18. " " sandy soil	25·6	4·1	22·4	
19. Heligoland bean on clay soil	19·6	—	18·3	
20. " " sandy soil	21·1	0·2	25·6	

1. Analysed by **Bichon**(Handw. d. Chem. 2te Aufl. ii. [2] 259).—2. **Boussi**
(*ibid.*)—3. By **Büchner** (*ibid.*)—4–10 and 16–20. **Way** and **Ogston** (Jo
the Royal Agricultural Society, ix. pt. 1).—11. **Levi** (Handw.)—12. **Boussi**
(*ibid.*)—13. **Thon** (*ibid.*)—14. **Richardson** (Jahresber. f. Chem. 1847, 1848,
Tafel C).—15. **Hertwig** (Handw.) This contained carbonic acid, which
deducted.

The pods of *Phaseolus multiflorus* contain, according to **T. J. Herapath** (Ch
Qu. J. 4), 94·1 per cent. water; air-dried, they yielded 0·631 per cent., and, aft
at 100° C., 10·7 per cent. of ash, containing:—

Of matter soluble in water: 14·1 carbonic anhydride; 3·4 sulphuric anhy
1·5 phosphoric anhydride; 36·1 potash; 4·9 chloride of sodium.

Of matter insoluble in water: 22·2 carbonate of calcium; 3·8 carbonate o
nesium; 11·9 phosphate of calcium; and 2·1 silica.

BEAUMONTITE. A mineral found in the gneiss at Jones Falls ne
more, in North America, in square pyramids, having terminal dihedral angle
28′, and the lateral edges replaced by the square prism ∞ P.

Cleavage parallel to ∞ P. Yellowish-white to honey-yellow, transluce
nacreous lustre. Specific gravity 2·24. Hardness 4·5 to 5·0. According to
(Ann. Ch. Phys. [3] ix. 385), it contains 64·2 silica, 14·1 alumina, 4·8 lime,
nesia, 1·2 protoxide of iron, 0·6 soda (and loss), 13·4 water. Alger and Da
opinion that the mineral thus characterised is merely stilbite, the form of
been incorrectly determined, and the analysis made with impure material.

xcix. 125), found, in the unripe seeds, another kind of sugar, which he at garded as a peculiar substance, designated by him as *phaseomannite*, from its lance to mannite. According to later investigations, however, it appears to be al with inosite, the saccharine substance which Scherer obtained from muscular

s of Bean Seed and Bean Straw.

Sulphuric anhydride, SO^3.	Silica, SiO^2.	Carbonic anhydride, CO^2.	Phosphoric anhydride, P^2O^5.	Chloride of potassium, KCl.	Chloride of sodium, NaCl.	Ash per cent.	
						In substance undried.	In substance dried at 100° C.
1·3	2·4	—	38·0	—	2·4		
1·6	0·5	1·0	35·7	1·5			
—	0·5	—	40·5				
3·0	0·4	3·4	28·7	—	—	2·37	2·65
4·3	1·5	1·6	33·7	—	3·2	2·85	3·43
3·1	0·4	3·4	36·7	—	—	2·68	3·01
3·1	0·4	0·8	26·9	0·9	1·8	2·48	2·97
5·1	2·2	2·6	29·9	—	—	2·54	2·90
6·2	0·7	2·8	30·6	—	3·2	2·53	2·94
5·3	0·04	0·3	33·3	1·2	3·2	2·80	3·83
2·5	0·4	—	31·3	—	0·5		
1·3	1·0	3·3	28·4	0·2			
2·3	1·5	—	35·9	—	3·4		
4·0	4·1	—	17·0	—	2·8	0·68	
2·1	11·3	—	12·1	—	0·4		
1·4	2·6	25·3	0·5	—	11·5	4·97	5·56
1·4	2·2	24·4	6·5	—	10·0	5·17	5·81
5·4	4·6	22·6	3·3	—	6·9	4·64	5·05
3·9	1·5	25·7	11·1	3·6	11·0	6·47	7·24
2·1	7·3	18·1	8·4	—	8·3	6·05	6·69

name *Beaumontite* is also given by Jackson to a variety of siliceous malachite, allied mineral containing silica, water, and oxide of copper.

BIRIC ACID. An acid contained, according to Maclagan, in the bark of *beeru* or *Sipeeri* (*Nectandra Rodiei*), a tree growing in British Guiana. To obne acid, the bark is exhausted with water acidulated with acetic acid; the , bebirine and sepirine, with which the acid is in combination, are precipitated monia; the filtered liquid is precipitated by acetate of lead; the precipitate posed by sulphuretted hydrogen; the clear liquid evaporated over sulphuric and the residue digested in ether, which dissolves the acid, but leaves the ng matter. On evaporating the ethereal solution, bebiric acid remains as a crystalline substance, having a waxy lustre. By exposure to the air, it is gra- reduced to a syrupy liquid. It melts a little above 200° C., and sublimes in f needles. With potash and soda, it forms deliquescent salts soluble in alcohol; gly soluble salts with the alkaline earths; the lead-salt also is but sparingly in alcohol.

BIRINE or **BEBEERINE.** $C^{19}H^{21}NO^3$ or $C^{38}H^{21}NO^6$.—An alkaloid dis- l in 1834 by Dr. Rodie of Demerara, in the bark of the bebeeru tree (*vid. sup.*). gan, in 1843 (Ann. Ch. Pharm. xlviii. 106), showed that Rodie's bebirine mixture of two distinct alkaloids, which he denominated *bebirine* and *sepirine*. rmer of these was more exactly investigated in 1845 by Maclagan and Tilley Mag. xxvii. 186), who assigned to it the formula $C^{35}H^{20}NO^6$. But bebirine

was first obtained perfectly pure by v. Planta (Ann. Ch. Pharm. lxxvii. 332
assigned to it the formula above given.

Preparation.—1. The bark is exhausted with water containing sulphuric aci
extract is concentrated, filtered, and precipitated by ammonia; and the preci
consisting of bebirine, sepirine, and tannin, is dried, dissolved in acidulated
and decolorised with animal charcoal. The solution again decomposed by am
yields a nearly colourless precipitate of bebirine and sepirine. As, howev
treatment with animal charcoal always occasions a certain loss of alkali, it is be
triturate the precipitate while yet moist with oxide of lead or milk of lime, d
mixture over the water-bath, extract the two alkaloids by means of alcoh
evaporate the alcoholic solution. To separate the two alkaloids, the product
hausted with ether, which dissolves only the bebirine (Maclagan and Till
2. The bebirine prepared by the process just described, is not quite pure, an
not dissolve completely in ether. It may be purified by treating it with acet
adding acetate of lead to the filtrate, precipitating the mixture with caustic
washing the precipitate with a large quantity of cold water, and redissolving in
The ethereal solution, when evaporated, leaves the bebirine in the form of
yellow syrup, which is dissolved in a small quantity of strong alcohol, and the s
is added drop by drop to a considerable quantity of water, with constant agi
bebirine then separates in the form of a floculent precipitate. (v. Planta.)

Bebirine when dry, is a white, amorphous, odourless powder, which does not
by exposure to the air, and becomes electrical by friction. It melts at 198°
vitreous mass, which decomposes at a higher temperature. — By boiling with
nitric acid, it is converted into a yellow pulverulent substance. Heated with c
acid, it yields a black resin. It does not yield chinoline when heated with
potash.

Bebirine is nearly insoluble in water, but dissolves readily in alcohol and
especially with the aid of heat. The solution has an alkaline reaction, and
persistent bitter taste. It dissolves readily in acetic and hydrochloric acid, f
bitter uncrystallisable salts. It is precipitated from its solutions by dilute
acid.

Hydrochlorate of bebirine is very soluble in water; and the solution treate
caustic alkalis or their carbonates yields bebirine in white flakes, easily soluble
cess of the reagents. The *chloromercurate* is obtained by adding mercuric c
to the solution of the hydrochlorate; a small quantity of hydrochloric acid or c
of ammonium increases the precipitate; but an excess redissolves it. The *chlor*
is a brown-red precipitate. The *chloroplatinate*, $2(C^{19}H^{21}NO^{3}.HCl).PtCl^{4}$, is an c
yellow amorphous precipitate, insoluble in hydrochloric acid. The *sulphocya*
a white precipitate; the *picrate* yellow.

Sulphate of bebirine in the impure state has been used as a remedy in inter
fever.

The bark of the bebeeru tree, which has a bitter and astringent taste, c
about 2·5 per cent of bebirine and sepirine, together with bebiric acid and a p
tannin; the seed contains the same principles, together with about 50 per c
starch, which impedes the extraction of the bases and acid.

BECKITE. This name has been given to a mineral from Paynton in Devo
which, according to Kenngott, is merely a coral hardened into a chalcedonic o
stone variety of quartz, intergrown with compact grey limestone.

BEECH. *Fagus sylvatica.*—Beech-wood recently felled, has a specific gra
0·982, and contains 40 per cent. water; after drying in the air, it has a specific
of 0·590, and contains 18 to 20 per cent. water. After drying at 100° C. it co
according to Baer (Arch. Pharm. [2] lvi. 159), 46·1 to 48·3 per cent. carbon
6·0 hydrogen, 46·6 to 45·1 oxygen, and 1·2 to 0·6 ash. According to Cheva
(Compt. rend. xxiv. 269), it contains 49·8 per cent. C, 6·0 H, 43·1 O, 1·1
yields 1·06 per cent. ash. According to Sprengel (J. techn. Chem. xiii. 38
air-dried wood yields 0·365 per cent. ash, containing 0·14 crude carbonate of p
and the leaves which fall in autumn yield 6·695 per cent. ash.

The following table exhibits the composition per cent. of the ash of beech-wo
of the leaves. *a*, *g*, *h* are by Sprengel (*loc. cit.*); *b*, *c* (Witting, Pharm.
1851, 104); *b*, of wood grown on sandstone (*bunter Sandstein*), near Marbur
wood grown on the Muschelkalk, near Morschen in Kurhessen; *d*, *e*, *f* (Hey
Vonhausen, Ann. Ch. Pharm. lxxxii. 180). The wood was grown on a
hill near Giessen. A hectare of surface produced yearly 2·672 cubic metres o
wood (*Scheitholz*); 0·965 c. m. large branch-wood (*Prügelholz*); 0·769 c. m
branch-wood (*Stockholz*); and 1·878 c. m. of twigs (*Reisholz*); and these qu

tracted from the soil, in all, 51·3 kilogrammes of ash, viz. the stem-wood he large branch-wood 9·9 kil., the small branch-wood 4·9 and the twig- kil. Hence a cubic metre of the stem-wood yields 6·342 kilogrammes large branch-wood 10·233 kil.; and of twig-wood 14·144 kil. The table that, reckoning from the bottom upwards, the proportion of *alkali* dimi- of the *phosphoric* and *sulphuric acid* increases; while of *silica*, the twigs than the stem, and the thick branches least of all.

	Wood.			Wood with Bark.			Leaves.	
				Stem.	Large Branches.	Twigs.		
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
	24·9	10·9	6·9	13·1	12·5	11·8	—	5·1
	1·1	1·2	0·3	3·1	1·7	1·8	0·7	1·0
	27·4	13·5	43·6	29·8	37·3	40·2	51·7	37·7
	6·6	12·0	5·4	10·1	13·4	9·0	6·1	7·9
	2·2	0·05	—	—	—	—	1·1	
	—	—	0·6	0·5	0·3	0·6	0·8	0·4
ide	7·4	3·4	trace	0·9	1·0	0·6	4·1	2·4
nhydride	7·1	1·0	0·6	0·4	0·5	1·0	1·9	1·3
	5·2	6·3	2·1	6·2	5·5	8·2	27·0	28·5
hydride	—	26·2	28·3	19·6	17·4	16·3	—	10·5
	—	5·6	7·5	6·0	9·6	10·3	6·6	4·8
hate	15·1							
sodium	2·6	6·7	0·6	0·1	0·8	0·1	—	0·3
	—	2·1						
	—	10·7	3·7					

k of the beech contains, together with the usual constituents of vegetable about 2 per cent. of tannin, also a peculiar red substance, and another ls like vanilla. The latter is soluble in alcohol, insoluble in water and in by shaking up the alcoholic solution with hydrate of lead, and repeated n by water, it may be obtained as an amorphous white powder, with an nilla and a bitter taste. It dissolves in acetic acid and in alkalis; nitric ts it into oxalic acid. (Lepage, J. Pharm. [3] xii. 181.)

h-bark yields about 0·6 per cent. crude potash. According to Hertwig Pharm. xlvi. 97), it yields 6·6 per cent. ash, containing in 100 pts. 3·0 s, consisting of alkaline carbonates, sulphate of potassium, and a trace of sodium, and 97·0 pts. of insoluble salts, viz. 64·7 carbonate of calcium, sia, 2·7 phosphate of calcium, 1·9 phosphates of magnesium, aluminium, nd 9·0 silica.

of beech-nuts yields in 100 pts. 18·1 K^2O, 7·5 Na^2O, 19·5 CaO, 9·2 MgO, 16·5 P^2O^5, 0·7 NaCl, 1·5 SiO^2, 9·1 CO^2, and 9·4 charcoal. (Handw. d. Chem. [2] 549.)

-NUT OIL. *Huile de faine.* $C^{18}H^{28}O^2$.—Beech-nuts yield, by pressure, r cent. of a clear, light-yellow, viscid oil, inodorous, having a mild taste and of 0·9225 at 15° C. It solidifies at 17° C., and is coloured rose-red by It is a non-drying oil, and yields a white soap. It is used in cooking and tion. Mixed with eight or ten times its bulk of water, and treated at 60° th *chlorine* gas, it is converted into a chlorinated oil containing $C^{18}H^{28}Cl^2O^2$. ts on it with violence, but if the oil be cooled at the same time, the com- $^{28}Br^2O^2$ is produced. (Lefort, Compt. rend. xxxv. 734.)

is the wine of grain, and is prepared from malt, or grain, generally barley, been allowed to germinate. The grain is steeped for two or three days in l it swells, becomes somewhat tender, and tinges the water of a bright wn colour. The water being then drained away, the barley is spread about ck upon a floor, where it heats spontaneously, and begins to grow by first t the radicle. In this state, the germination is stopped by spreading it l turning it over for two days; after which it is again made into a heap, l to become sensibly hot, which usually happens in little more than a day. conveyed to the kiln, where, by a gradual and low heat, it is rendered dry This is malt, and its qualities differ according as it is more or less soaked, rminated, dried, and baked.

distinguished by its colour, as pale, amber, brown, or black malt, according to the different degrees of heat to which it has been subjected. Pale ma produced when the drying temperature does not exceed 90° to 100° F., an coloured malt when the heat has been raised to 120° to 125°, and brown malt at to 170°. Black malt, commonly called patent malt, is prepared by roastin cylinders like coffee, at a heat of 360° to 400° F.; it is used as colouring matter i brewery of porter.

Indian corn, and probably all large grain, requires to be suffered to grow into blade, as well as root, before it is fit to be made into malt. For this purpose, buried about two or three inches deep in the ground, and covered with loose e and in ten or twelve days it springs up. In this state, it is taken up and washe fanned, to clear it from dirt; and then dried in the kiln for use.

During the process of germination, the albuminous matter of the barley or grain is brought into the peculiar state called *diastase*, in which it acts as a fer on the starch contained in the grain, converting it into dextrin and sugar, and the rendering it soluble. A portion of the starch is, however, always left unchange the germinating process, and its conversion into dextrin and sugar is complete the kiln-drying. The benefit of this latter process is, therefore, not confined t mere expulsion of moisture from the grain; indeed kiln-dried malt always yie larger quantity of saccharine extract than malt which has been left to dry in the ordinary temperatures.

The diastase of malt is capable of converting into sugar a much larger quanti starch than that which the grain itself contains: hence in the preparation of th tract, the malt may be mixed with a certain quantity of unmalted barley or grain. In Belgium, large quantities of beer are prepared from malt mixed potato starch.

To make beer, the malt, after being ground or cut to pieces in a mill, is placed tun or tub with a false bottom; water at about 180° F. is then poured upon it the whole is well stirred about by suitable machinery. This operation is called *ing*. After the infusion has been left for a few hours to clarify or *set*, the clear l or *sweet wort* is transferred to a copper boiler and boiled with hops, which give bitter aromatic taste, and perhaps also render it less liable to spoil by kee When the wort has been sufficiently boiled, it is drawn from the copper into shallow vessels, so as to cool it as rapidly as possible to the temperature of the and thereby avoid an irregular acid fermentation, to which it would otherwise be li It is then transferred to the fermenting vats, which in large breweries are of capacity, and mixed with yeast, the product of a preceding operation. The liqu thereby brought into a state of commotion; the sugar is more or less converted alcohol and carbonic acid, which escapes as gas; and the nitrogenous matter o extract is converted into yeast, part of which is expended in keeping up the ferm tion, while the rest rises to the surface. The fermentation is never suffered to its full course, but is always stopped at a certain point, by separating the yeast drawing off the beer into casks. A slow and almost insensible fermentation takes place, whereby more of the sugar is converted into alcohol, and the beer is ren stronger and less saccharine.

During this last process, the beer gradually becomes clear or fine, the solid ticles of yeast which float about in it during the fermentation, and render it mu being gradually brought to the surface and discharged through the bung-holes o casks, whence the yeast is conveyed into proper receptacles. A very effectiv rangement for this purpose is adopted at the extensive breweries of Messrs. Bas Allsopp at Burton-on-Trent, for a description and figure of which see *Musp Chemistry*, vol. i. p. 276. Frequently, however, it is found necessary to assis clarification by means of substances called *finings*, which lay hold of the suspe matter, and precipitate it to the bottom. Isinglass dissolved in sour beer is used for this purpose, also gelatin, white of egg, serum of blood, Carragheen and the dried stomach of the cod, called *sounds*. It is best, however, when clarification takes place spontaneously, without the use of finings; for all these stances tend to make the beer flat, and prevent it from carrying a good head. composition of the water used in brewing has a great influence on the result. in particular appears to favour the clarification, by combining with the aci the malt-extract, and forming insoluble salts, which carry down the suspe matter. The spring-water of Burton-on-Trent (not that of the river Trent) con 19 per cent. of sulphate of lime, only a small portion of which is precipitate boiling.

The strength and taste of beer are susceptible of endless variety, according t quality and quantity of the malt and hops used, and the mode of conducting stage of the process, but especially the fermentation. If the first fermentatio an early stage, the beer will contain a considerable quantity of sugar and ely little alcohol: it will be mild, and if bottled, will acquire the property ing strongly when the bottle is opened, because the carbonic acid produced sequent slow fermentation, remains dissolved in the liquid, and escapes with soon as the pressure is removed. If, on the other hand, the fermentation to go on in the vat or in casks, till nearly all the sugar is converted into d the carbonic acid escapes, the beer then becomes more alcoholic; but if be allowed to go on too long, it loses its briskness and becomes flat and e. *Strong* beers are those which contain a considerable amount of alcohol; beers are those which are rich in malt-extract; the latter are also said to *ly.*

t-liquors consumed in this country are of two kinds, ALE and PORTER. Ale from the paler kinds of malt, and in its preparation, the first fermentation at such a stage as to leave a considerable quantity of saccharine matter in which, by its subsequent conversion into alcohol and carbonic acid, may e briskness. The ale is mild or bitter, according to the quantity of hops e wort. *Pale ale* is prepared from the palest malt dried in the sun or by , and from the best and palest hops. An essential point in its preparation the fermenting temperature as low as possible, never allowing it to rise F. By this means, the formation of acetic acid is prevented, as also the the yeast by alcohol, which always communicates an unpleasant flavour to —and the delicate flavour and aroma of the hop are preserved. *Scotch ale* strong ale; it was formerly flavoured with honey, but that practice appears abandoned.

a dark-coloured beer, prepared from a mixture of pale, amber, brown, and . The following table (taken from Muspratt's Chemistry) exhibits the of the various mixtures employed:

Table of Porter Grists.

Black.	Brown.	Amber.	Pale.	Total.
9	0	0	91	100
6	34	0	60	100
2	30	10	58	100
3	25	15	57	100
4	24	24	48	100
5	0	95	0	100

e preference is given to the last two; in the others, the excess of black and t introduces too much carbonaceous and useless matter, whence the porter disagreeable taste, as if liquorice were added to it. The fermentation of he vats is carried on till the original gravity of the liquid is reduced to third. *Stout* is merely a stronger kind of porter. *Small beer*, as its name a weaker liquor, and is made either by adding a large quantity of water to r by mashing with a fresh quantity of water, the residuum left after ale or been drawn off.

nperature at which the fermentation of beer is conducted, has a marked ts quality, and especially on its power of keeping without turning sour. fermenting temperature ranges from 65° to 90° F., as is the case with the ngland, France, Belgium, and most parts of Germany, the beer gradually ur by contact with the air, the alcohol being slowly converted into acetic Bavarian beer, which is fermented at a much lower temperature, 8° or 10° 50° F.), does not undergo this change. The difference arises from the which the fermentation takes place, and is explained by Liebig as follows: oportionally richer in soluble gluten than in sugar, and when set to ferment nary way, it evolves a large quantity of yeast in the state of a thick froth, les of carbonic acid gas adhering to it, whereby it is floated to the surface id. Now the conversion of gluten into yeast is partly, at least, a process of and when the liquor is covered with a thick scum, as just described, the l dissolved in the liquid, not having free access to the air, appears to take m the sugar and other matters contained in the liquid, the formation of the going on at the expense of the sugar, which is consequently destroyed before of the gluten is converted into yeast. From this cause, a quantity of free ft in the liquid, and on subsequent exposure to the air, this gluten acts as inducing the conversion of the alcohol into acetic acid. In the Bavarian the contrary, the carbonic acid, instead of escaping in large bubbles, which, yeast to the surface, rises in minute bubbles in the same manner as from an effervescing mineral water; little or no scum forms on the surface, but the yea it is produced, sinks to the bottom, and leaves the surface of the wort freely ex to the air. The gluten is thus converted into yeast by atmospheric oxidation, and last wholly removed from the liquid without decomposition of the sugar. Bee fermented, is not liable to acidification by exposure to the air.

The kind of fermentation last described, is called *bottom fermentation* (*U gahrung*), and the yeast produced by it *bottom yeast* (*Unterhefe*); while the nary fermentation process is called *top fermentation* (*Obergahrung*), and yeast which it produces *top yeast* (*Oberhefe*). These two kinds of yeast essentially in their properties and mode of action. The top-yeast is gluten oxidi a state of putrefaction, and the bottom yeast is the gluten oxidised by *eremaca* slow combustion. Each of them has a tendency to induce the particular kind mentation by which it was itself produced. (See Fermentation.)

For further details respecting the preparation and properties of beer, see the a Beer and Brewing in the new edition of *Ure's Dictionary of Arts, Manufacture Mines;* also the article Beer in *Muspratt's Chemistry*, and in the *Handwört der Chemie*, 2te Aufl. ii. [1] 103·6

Analysis of Beer. — The normal constituents of beer are alcohol, carboni and extractive matters of malt and hops; acetic acid is also present, but its a in good beer is very small.

The amount of carbonic acid in beer is but small, not exceeding 0·1 to 0 cent. even in bottled beer, and of this small quantity the greater portion e as soon as the beer is opened. The strength of the frothing will give a ver idea of its relative amount. An exact estimation of the carbonic acid is seldom necessary; but if desired, it may be made by boiling a known quan the beer in the flask-apparatus, represented in *fig. 5*, p. 119, (art. Alkalim The carbonic acid (anhydrous) then escapes as gas, while the vapours of and alcohol given off at the same time are retained by the chloride of calci the drying tube.

The amount of acetic acid is estimated by the usual processes of Acidi (*q.v.*)

The quantity of extractive matter in beer may be determined by evap 20 grammes of beer in a platinum or porcelain dish, and drying the residue in bath (p. 520) at 100°—115° C. till it ceases to lose weight. Before weigh must be cooled under a bell-jar over chloride of calcium, as it is very hygroscop

It is seldom necessary to examine the extractive matter any further. It mainly of sugar, dextrin, albuminous matter, and lupulin, the bitter principle hop. The amount of dextrin and sugar may be determined by moistening th residue with water to a thin syrup, and gradually adding strong alcohol as long as is thereby separated. The clear sugar-solution may then be decanted, and the freed from the remaining sugar by repeated solution in water and precipita alcohol. The solutions of dextrin and sugar may then be evaporated to dryne the residues weighed. The albuminous matter may be estimated from a separa tion of the beer by boiling it so as to coagulate the albumin, collecting the pre on a tared filter, then washing, drying, and weighing it. Lastly the sum weights of the dextrin, sugar, and albuminous matter, deducted from the total of the extract gives the quantity of lupulin.

The inorganic constituents of beer are estimated by evaporating to dr known quantity of the beer, charring the residue, and then igniting it, as in the p tion of plant-ashes (p. 419). They consist chiefly of the phosphates of calci magnesium. Alkaline phosphates may likewise be found, but the greater them is dissolved out during the maceration of the barley for malting. Comm which is sometimes added to beer, will of course be found in the ash. Any co able amount of alkaline carbonate may be attributed to alkali added to neutral acid in the beer.

The amount of alcohol in beer is ascertained by distilling 500 to 1000 g (15 to 30 ounces) in a somewhat capacious retort, having its neck inclined upwa connected with a Liebig's condenser, receiving the distillate in a tared flask, w it, and determining its specific gravity at 15⅝ C. (60° F.), that of water at th temperature being assumed = 1·000; or the proportion of alcohol may be fo testing the distillate with a delicate alcoholometer. The weight per cent. of al then found by means of table A, which is an amplification of part of tha under Alcoholometry (p. 81), and thence the total amount of alcohol in th quantity of beer may be found.

Suppose, for instance, 1000 grms. of beer gave 615·38 grms. of distillate of rity 0·98949 at 60° F.; then, according to the table, the distillate would contain per cent. alcohol, and therefore the 615·38 grms. of distillate would contain 37·6 s. alcohol. Now these 37·6 grms. of alcohol were obtained from 1000 grms. of beer; equently the amount of alcohol in the beer is 3·76 per cent. The trouble of ulation may be saved by diluting the distillate till its weight becomes equal to of the beer employed; the specific gravity will then at once give the percentage veight of alcohol in the beer. If, for example, the distillate after dilution exhibited ecific gravity = 0·9932, the percentage of alcohol would be 3·76. If a Tralles' holometer were used, it would show in the distillate, before dilution, a percentage volume of 7·6, corresponding to 6·11 by weight. In using the alcoholometer, it is not to dilute the distillate, unless the instrument is especially graduated for very k liquids. If the observed specific gravity or alcoholometer-degree does not occur he table, the weight per cent. of alcohol will be found by interpolation.

TABLE A.—*Specific Gravity and Strength of Spirits.*

Volume er cent.	Weight per cent.	Specific Gravity.	Volume per cent.	Weight per cent.	Specific Gravity.
1·	0·80	0·99850	4·5	3·60	0·99350
1·1	0·88	0·99835	4·6	3·68	0·99336
1·2	0·96	0·99820	4·7	3·76	0·99322
1·3	1·04	0·99805	4·8	3·84	0·99308
1·4	1·12	0·99790	4·9	3·92	0·99294
1·5	1·20	0·99775	5·0	4·00	0·99280
1·6	1·28	0·99760	5·1	4·08	0·99267
1·7	1·36	0·99745	5·2	4·16	0·99254
1·8	1·44	0·99730	5·3	4·24	0·99241
1·9	1·52	0·99715	5·4	4·32	0·99228
2·0	1·60	0·99700	5·5	4·40	0·99215
2·1	1·68	0·99686	5·6	4·48	0·99202
2·2	1·76	0·99672	5·7	4·56	0·99189
2·3	1·84	0·99658	5·8	4·64	0·99176
2·4	1·92	0·99644	5·9	4·72	0·99163
2·5	2·00	0·99630	6·0	4·81	0·99150
2·6	2·08	0·99616	6·1	4·89	0·99137
2·7	2·16	0·99602	6·2	4·97	0·99124
2·8	2·24	0·99588	6·3	5·05	0·99111
2·9	2·32	0·99574	6·4	5·13	0·99098
3·0	2·40	0·99560	6·5	5·21	0·99085
3·1	2·48	0·99546	6·6	5·30	0·99072
3·2	2·56	0·99532	6·7	5·38	0·99059
3·3	2·64	0·99518	6·8	5·46	0·99046
3·4	2·72	0·99504	6·9	5·54	0·99033
3·5	2·80	0·99490	7·0	5·62	0·99020
3·6	2·88	0·99476	7·1	5·70	0·99008
3·7	2·96	0·99462	7·2	5·78	0·98996
3·8	3·04	0·99448	7·3	5·86	0·98984
3·9	3·12	0·99434	7·4	5·94	0·98972
4·0	3·20	0·99420	7·5	6·02	0·98960
4·1	3·28	0·99406	7·6	6·11	0·98949
4·2	3·36	0·99392	7·7	6·19	0·98936
4·3	3·44	0·99378	7·8	6·27	0·98924
4·4	3·52	0·99364	7·9	6·35	0·98912
			8·0	6·43	0·98900

The residue in the retort may be used for determining the amount of extractive tter in the beer. For this purpose it is diluted with water, after cooling, till its ght becomes equal to that of the beer before distillation, and the amount of extrac- matter is then found from its specific gravity, by means of tables provided for the pose.

The following is taken from a more detailed table in the *Handwörterbuch*, 2te Aufl. ii. 1081.

Table B.—*Specific Gravity and Strength of Malt-Extract.*

Specific Gravity.	Malt-extract in 100 pts. of liquid.	Specific Gravity.	Malt-extract in 100 pts. of liquid.	Specific Gravity.	Malt extract in 100 pts. of liquid.	Specific Gravity.	Malt-e in 10 of li
1·000	0·000	1·018	4·500	1·036	8·925	1·054	13·
1·001	0·250	1·019	4·750	1·037	9·170	1·055	13·
1·002	0·500	1·020	5·000	1·038	9·413	1·056	13·
1·003	0·750	1·021	5·250	1·039	9·657	1·057	13·
1·004	1·000	1·022	5·500	1·040	9·901	1·058	14·
1·005	1·250	1·023	5·750	1·041	10·142	1·059	14·
1·006	1·500	1·024	6·000	1·042	10·381	1·060	14·
1·007	1·750	1·025	6·244	1·043	10·619	1·061	14·
1·008	2·000	1·026	6·488	1·044	10·857	1·062	15·
1·009	2·250	1·027	6·731	1·045	11·095	1·063	15·
1·010	2·500	1·028	6·975	1·046	11·333	1·064	15·
1·011	2·750	1·029	7·219	1·047	11·595	1·065	15·
1·012	3·000	1·030	7·463	1·048	11·809	1·066	16·
1·013	3·250	1·031	7·706	1·049	12·047	1·067	16·
1·014	3·500	1·032	7·950	1·050	12·285	1·068	16·
1·015	3·750	1·033	8·195	1·051	12·523	1·069	16·
1·016	4·000	1·034	8·438	1·052	12·761	1·070	17·
1·017	4·250	1·035	8·681	1·053	13·000		

A more extended table of the specific gravity of pure syrup, which does not greatly from that of malt-extract, is given in *Ure's Dictionary of Arts, Manufac and Mines*, new edition, vol. ii. p. 610.

The amount of alcohol in beer may in most cases be calculated with suff accuracy for practical purposes, from the difference between the specific gravity boiled and unboiled beer, according to the following principle: *The specific grav the unboiled beer is less than that of the boiled beer, in the same proportion as the sp gravity of spirit of wine of equal alcoholic strength is less than that of water.* determine the amount of alcohol in beer accordingly, the beer is first freed fro bonic acid by brisk agitation in a capacious flask, assisted perhaps by very g warming, and its specific gravity is accurately determined. It is then boiled to off the alcohol, and the residue is diluted with water, till its weight becomes ex equal to the original weight of the beer; it is then filtered, if necessary, throu covered filter, and its specific gravity likewise determined. The amount of alcoh then calculated, as in the following example. Suppose the specific gravity of the unb beer, freed from carbonic acid, to be 1·0250; and after boiling and dilution water, to be increased to 1·0320. Then, according to the principle just stated specific gravity of pure spirit of the same alcoholic strength as the beer, will that of water as 1·0320 : 1·0250; that is to say, it will be $\frac{1\cdot0250}{1\cdot0320} = 0\cdot9932$, which cording to the table, page 531, corresponds to 3·8 per cent.

The empirical rule for finding the specific gravity of spirit of equal strength the beer is: *Divide the specific gravity of the unboiled beer by that of the boiled after its original weight has been restored by dilution.*

It is clear that the results obtained by this method (called in Germany the *Sp Beer-test*), will be more exact, in proportion as the composition of the beer differe from that of pure spirit of equal strength, in other words, the smaller the amou of the extractive matter contained in the beer. For beers like those of Bavar answers very well; but for those which contain a larger amount of extract it ca be relied on.

For **Balling's** *Saccharometric method* (*saccharimetrische Bierprobe*), and **Fuc** *Hallymetric method* (*hallymetrische Bierprobe*), which latter consists in determi the quantities of alcohol and extractive matter in beer by the quantity of com salt which it is capable of dissolving, see *Handwörterbuch der Chemie*, 2^{te} Au [1] 1078; and *Handbuch der technisch-chemischen Untersuchungen* von P. A. Bo 2^{te} Aufl. Leipzig, 1861, s. 350.

The following tables C and D, exhibit the composition of various kinds of be See also *Jahresbericht für Chemie*, 1849, p. 708; 1850, p. 683; 1853, p. 758; p. 852.

—*Average Amount of Malt-extract and Alcohol in various Kinds of Beer.*

Name of Beer.	Percentage of	
	Malt-extract.	Alcohol.
le, for exportation	7—5	6—8
le, ordinary	5—4	4—5
rter, for exportation	7—6	5—6
rter, ordinary	5—4	3—4
ambik	5·5—3·5	4·5—6
aro	5—3	2·5—4
de Strasbourg	4—3·5	4—4·5
che de Paris	8—5	3·5—4
Beer	6·5—4	3—4·5
r of Berlin	6·2—5·7	1·8—2

BLE D.—*Special Results of the examination of certain Beers.*

Name of Beer.	Percentage of				Analysed by
	Malt-extract.	Alcohol.	Carbonic acid.*	Water.	
(Barclay and Perkins)	6·0	5·4	0·16	88·44	Kaiser.
	6·8	6·9	—	86·3	Balling.
(Berlin)	5·9	4·7	0·37	89·0	Ziurek.
	14 5	5·9	—	79·6	Hoffmann.
linburgh)	10·9	8·5	0·15	80·45	Kaiser.
	6·3	7·6	0·17	85·93	Ziurek.
ik	3·4	5·5	0·2	90·9	Kaiser.
	2·9	4·9	0·2	92·0	Kaiser.
München	9·4	4·6	0·18	85·85	Kaiser.
chen	9·2	4·2	0·17	86·49	Kaiser.
ght beer (*Schenkbier*) München	5·8	3·8	0·14	90·26	Kaiser.
-beer (*Lager-bier*) München s old	5·0	5·1	0·15	89·75	Kaiser.
-beer, München	3·9	4·3	0·16	91·64	Kaiser.
ght-beer, Brunswick	5·4	3·5	—	91·1	Otto.
Waldschlösschen	4·8	3·6	—	91·5	Fischer.
t-beer	6·9	2·4	—	90·7	Balling.
Beer (*Stadt-bier*)	10·9	3·9	—	85·2	Balling.
unswick	14·0	1·36	—	84·7	Otto.
erlin	2·6	2·6	0·5	94·3	Ziurek.
n Beer, Berlin	3·1	2·3	0·3	94·2	Ziurek.
rlin	5·7	1·9	0·6	91·8	Ziurek.
le Louvain	3·0	4·0	—	93·0	Le Cambre.
uvain	4·0	6·5	—	89·5	Le Cambre.
ck	45·0	1·9	—	53·1	Freytag and Busse.

ng are examples of the percentage composition of the ash of beer, the first by Walz (Jahrb. pr. Pharm. iii. 312; Jahresber. f. Chem. 1855, p. 892), ickson (Phil. Mag. xxxiii. 341; Jahresber. 1847-8, p. 1112).

TABLE E.—*Ash of Beer.*

	London Beer.	From München.	From Speyer.	Scotch Ale (14 samples).	Scotch Porter (2 samples).	Dublin Porter (2 samples).	London Porter (5 samples).
	38·35	36·58	37·68	3·2—29·8	18·9—20·9	21·4—32·0	4·9 —31·1
	7·68	9·03	6·59	20·9 - 38·5	33·8—38·8	24·0—42·7	21·8 —50·8
	2·45	1·48	2·98	0·2— 2·0	1·3— 1·6	0 8— 1·5	0·8 — 6·9
	3·78	5·64	4·66	0·1— 5·6	0·2— 1·4	0·2— 1·2	0·1 — 1·2
(SO^3)	1·36	1·68	2·56	1·6—19·2	2·2— 6·4	2·8—10·1	1·6 —12·2
	2·75	3·14	2·14	4·3—18·25	7·4—11·4	6·9—10·1	6·5 —14·5
	9·87	9·96	10·29	4·6—19 1	13·3—18·6	6·9—19·7	8.25—19·7
(P^2O^5)	33·76	31·69	33·10	6·0—25·7	12·5—18·8	7·9—20·0	9·3 —20·6
	100·00	100·00	100·00				

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this column indicate that the carbonic acid was not determined quant'tatively in the nples.

Original Gravity of Beer-worts.—The conversion of sugar into alcohol b
mentation, is attended with a diminution of density in the liquid; consequentl
specific gravity of beer is always less than that of the wort before fermentation.
by the revenue-laws of this country, the brewer is allowed a drawback upon all
that is exported, the amount being regulated according to the original gravity o
wort. Hence it is necessary that the revenue officer be possessed of a meth
determining the original gravity, from the observed specific gravity and compo
of the beer, whereby he may check the record kept by the brewer.

If the non-volatile matter of beer consisted entirely of starch-sugar (glucose
determination of the original gravity would be a very easy matter: for it is
that every 1 per cent. of alcohol in beer corresponds very nearly to 2 per cen
sugar in the wort before fermentation: hence it would merely be necessary to d
the percentage of alcohol in the beer, add thereto the percentage of sugar as
by direct experiment, and the sum would be the total amount of sugar in 100 p
the unfermented wort; the specific gravity would then be given by a saccharom
table, such as Table B, p 532.

For example, London porter (No. 1, of Table D), contains 6·0 per cent. of
extract (which we shall suppose to consist of starch-sugar), and 5·4 per cent. al
the latter corresponding approximately to 10·8 per cent. starch-sugar. Hence the
quantity of extract in the unfermented wort would be 6·0 + 10·8 = 16·8, giv
specific gravity of 1·06.

But the actual problem to be solved is much less simple: for the wort co
several other substances, all differing more or less in specific gravity from starch-
Hence the exact determination of original gravities can only be effected by s
observations. The question has been examined by several foreign chemists, espe
by Balling of Prague, in his great work on Brewing*; in this country it has
investigated by Messrs. Dobson and Phillips, of the Department of Inland Re
and more recently by Professors Graham, Hofmann, and Redwood, from
"Report on Original Gravities," † the following observations are extracted.

The substances contained in beer-wort, in addition to starch-sugar, are: 1. *D*
which has not been converted into sugar in the process of mashing. 2. In ma
stances, *cane-sugar*, the use of which is now permitted in breweries. 3. *Ca*
arising either from high-dried malt, or from treacle or burnt-sugar, the use of
in the brewery of porter is also allowed by law. 4. A peculiar saccharine subs
called "extractive substance," resembling caramel, possessing decided acid prop
and not fermentable by yeast, even after boiling with sulphuric acid.‡ 5. Az
or albuminous matter, derived from the grain. 6. Alkaline and earthy salts.

The albuminous matter and the inorganic salts, have but little effect on the
parative densities of the wort before and after fermentation; but the dextrin,
sugar, caramel, and "extractive matter," all give solutions of less specific gravity
a solution of starch-sugar containing the same quantity of carbon, and the
capable of yielding an equal amount of alcohol. The differences are exhibited
following table.

TABLE F.—*Specific Gravities of Solutions of various* SACCHARINE SUBSTANCES, *a*
PALE *and* BROWN MALT *containing equal quantities of* CARBON.

Solution of Starch-sugar.	Solution of Cane-sugar.	Solution of Dextrin.	Solution of Extractive Substance.	Solution of Caramel.	Solution of Pale Malt.	Solution of Brown Malt.	Parts of C sugar corres ing in 1000 by Weigh Solutio
1010·4	1010·1	1009·7	1008·9	1008·7	1010·0	1010·0	25
1020·8	1020·2	1019·3	1017·8	1017·3	1020·3	1020·2	50
1031·3	1030·2	1028·8	1026·5	1026·2	1030·6	1030·6	75
1042·4	1040·6	1038·3	1035·5	1034·9	1041·2	1041·2	100
1053·5	1051·0	1047·9	1044·7	1043·8	1052·1	1052·0	125
1064·9	1061·8	1057·3	1053·9	1052·8	1063·0	1062·9	150
1076·0	1072·9	1066·9	1063·0	1062·3	1074·2	1074·0	175
1087·8	1083·8	1067·6	1072·7	1071·8	1085·5	1085·5	200
1099·4	1095·2	1086·3	1082·3	1081·3	1097·2	1097·2	225
1111·4	1106·7	1095·8		1091·0	1109·0	1109·0	250

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* *Die Gährungschemie wissenschaftlich begründet und in ihrer Anwendung auf die Weinberei
Bierbrauerei, Branntweinbrennerei, und Hefenerzeugung praktisch dargestellt.* Von Carl N. Bal
Prague, 1845. Or a shorter treatise by he same author: *Die saccharometrische Bier- und Brannt
meischprobe*. Prague, 1846. See also Handwörterbuch d. Chem. 2te Aufl. ii. [1] 1079.

† Chem. Soc. Q. J. v. 229.

‡ It probably contains glycerin and succinic acid, both of which substances have been show
Pasteur to be produced in alcoholic fermentation.

ese numbers plainly show that if an unfermented wort contains cane-sugar and
rin, and the gravity lost by fermentation is inferred from the quantity of alcohol
ined in the beer, on the supposition that the fermentable matter consisted wholly
rch-sugar, the estimated gravity will be too high; and on the other hand the con-
on of a portion of the fermentable sugar into unfermentable extractive matter, which
a solution of lower specific gravity for the same amount of carbon, will cause
stimate of the original gravity to come out too low; indeed, the extractive substance
ates only about five-sixths of the saccharine principle from which it is derived.

obviate these difficulties, the authors of the Report were led to propose, for the deter-
tion of original gravities, a purely empirical method, which consisted in ferment-
olutions of cane-sugar, starch, sugar, and malt-extract, of known original gravity,
making, at ten or twelve stages of the process, two following observations: 1. Dis-
g a convenient quantity (4 fluid ounces) of the fermented liquid in a retort as
ibed at page 530, diluting the alcoholic distillate with water, to the original
ne of the liquid, and taking its specific gravity; this deducted from the specific
ity of water (= 1000) gives the spirit-indication of the beer: *e.g.* if the
fic gravity of the alcoholic distillate after dilution is 985·95, the spirit-indication
·05. — 2. Diluting the boiled beer after cooling, to its original volume, taking its
fic gravity, and subtracting this, which is called the extract-gravity, from the
n original gravity of the wort before fermentation. The difference gives the
ber of *degrees of gravity lost*, corresponding to the spirit-indication previously
rved. The results of a long series of determinations of this kind on liquids of
n original gravity are given in the "Report" in the form of tables: of these we
quote only those which embody the general result of the inquiry, and are
ded for actual use in determining the original gravity of beer-worts.

able G (p. 536) is to be used when the spirit-indication of the beer is found by
llation in the manner above-mentioned. The first column gives the integers of
t-indication, the fractional parts (tenths) thereof being placed at the heads of the
r columns; the numbers in these several columns are the degrees of gravity lost
esponding to the several spirit-indications. Thus, suppose that a sample of beer
lled as above, gives a spirit-indication = 9·4, and extract-gravity = 1030·6. On
ninth line of the table, and in the column headed ·4, is found the number 41·2,
h is the *gravity lost*, and this added to the extract-gravity, gives 41·2 + 1030·6
071·8 for the original gravity of the wort.

s the distillation of the beer in a retort, and collecting of the entire quantity of
ol evolved, is an operation which occupies considerable time, and requires some
rience in manipulation, it is often desirable to obtain the spirit-indication of the beer
n easier process. This may be done by first taking the specific gravity of the beer
ived of carbonic acid by agitation, then boiling it in a flask till all the alcohol is
lled, diluting it to its original volume, and again taking its specific gravity. The
result, the *beer-gravity*, deducted from the second, the *extract-gravity*, is the
spirit-indication: thus if the beer before boiling has a specific gravity of 1044·7,
after boiling of 1035·1, the spirit-indication is 9·6 degrees. By numerous
riments in which the beer was boiled in a retort, and the alcoholic distillate
cted as above, it was found that the second method, the evaporation-method,
s a spirit-indication nearly equal to that resulting from the first or distillation-
od, but always sensibly less; thus the spirit-indication of a particular sample was
degrees by the first method, and 9·6 by the second. The experiments in question
made on liquids of known original gravity, and thus a series of determinations
obtained of the *relation between* the spirit-indication as determined by the
oration-method, and the degrees of gravity lost. The general results of the
iry, as applied to malt-worts, are given in the Table H, the arrangement of which
e same as that of Table G.

he authors of the Report likewise suggest a rational method of determining
inal gravities, which is interesting in a scientific point of view, though not expedi-
s enough for practical use. It is as follows: First determine the amount of alcohol
he beer by distillation. Then treat the residual liquid, which generally contains
starch-sugar and unfermentable extractive matter, with yeast, to complete the
entation, and determine the additional quantity of alcohol thus produced, making
rrection for that which is introduced by the yeast itself. Lastly, make up the
aining spiritless liquor with water to the original volume of the beer, and take its
ific gravity, a correction being also made for the increase of gravity caused by the
t. The quantity of starch-sugar corresponding to the corrected gravity of this
tion of extractive matter may now be found from a table provided for the purpose;
this, added to the amount of starch-sugar corresponding to the alcohol, gives the
l quantity of starch-sugar, from which the original gravity may be found by the
harometer tables.

Table G.—To be used in ascertaining Original Gravities by the Distilla
Process.

Degrees of Spirit-indication with corresponding Degrees of Gravity lost in
Worts.

Degrees of Spirit-indication.	0	·1	·2	·3	·4	·5	·6	·7	·8
0	—	0·2	0·6	0·9	1·2	1·5	1·8	2·1	2·4
1	3·0	3·3	3·7	4·1	4·4	4·8	5·1	5·5	5·9
2	6·6	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8
3	10·7	11·1	11·5	12·0	12·4	12·9	13·3	13·8	14·2
4	15·1	15·5	16·0	16·4	16·8	17·3	17·7	18·2	18·6
5	19·5	19 9	28·4	20·9	21·3	21·8	22·2	22·7	23·1
6	24·1	24·6	25·0	25·5	26·0	26·4	26·0	27·4	27·8
7	28·8	29·2	29·7	30·2	30 7	31·2	31·7	32·2	32·7
8	33·7	34·3	34·8	35·4	35·9	36·5	37·0	37·5	38·0
9	39·1	39·7	40·2	40·7	41·2	41·7	42·2	42·7	43·2
10	44·2	44·7	45·1	45·6	46·0	46·5	47·0	47·5	48·0
11	49·0	49·6	50·1	50·6	51·2	51·7	52·2	52·7	53 3
12	54·3	54·9	55·4	55·9	56·4	56·9	57·4	57·9	58·4
13	59·4	60·0	60·5	61·1	61·6	62·2	62·7	63·3	63·8
14	64·8	65·4	65·9	66·5	67·1	67·6	68·2	68·7	69·3
15	76·5								

Table H.—To be used in ascertaining Original Gravities by the Evapor
Process.

Degrees of Spirit-indication with corresponding Degrees of Gravity lost in
Worts.

Degrees of Spirit-indication.	0	·1	·2	·3	·4	·5	·6	·7	·8
0	—	0·3	0·7	1·0	1·4	1·7	2·1	2·4	2·8
1	3·5	3·8	4·2	4·6	5·0	5 4	5·8	6·2	6·6
2	7·4	7 8	8·2	8·7	9·1	9·5	9·9	10·3	10·7
3	11·5	11·2	12·4	12·8	13·2	13·6	14·0	14·4	14·8
4	15·8	16·2	16·6	17·0	17·4	17 9	18·4	18·8	19·3
5	20·3	20·7	21·2	21·6	22·1	22·5	23·0	23·4	23·9
6	24·8	25·2	25·6	26·1	26·6	27·0	27 5	28·0	28·5
7	29·5	30·0	30·4	30·9	31·3	31·8	32·3	32·8	33·3
8	34·3	34·9	35 5	36·0	36·6	37·1	37·7	38·3	38·8
9	40·0	40·5	41·0	41·5	42·0	42·5	43·0	43·5	44·0
10	44·9	45·4	46·0	46·5	47·1	47·6	48·2	48·7	49·3
11	50·3	50·9	51·4	51·9	52·5	53·0	53·5	54·0	54·5
12	55·6	56·2	56·7	57 3	57·8	58·3	58·9	59·4	59·9
13	61·0	61·6	62·1	62·7	63·2	63·8	64·3	64·9	65·4
14	66·5	67·0	67·6	68·1	68·7	69·2	69·8	70·4	70·9
15	72·0								

Adulteration of Beer.—The addition of extraneous substances to beer, to
colour and *heading*, or to provide cheaper substitutes for the bitter of the hop, a
to have been formerly carried to a great extent in this country. Dr. Ure says,
"*Dictionary of Chemistry*" 4th edition, 1831, p. 203: "As long ago as the re
Queen Anne, brewers were forbid to mix sugar, honey, Guinea pepper, essentia
cocculus indicus, or any other unwholesome ingredient, in beer, under a c
penalty; from which we may infer, that such at least was the practice of some
writers, who profess to discuss the secrets of the trade, mention most of these
some other articles, as essentially necessary. The essentia bina is sugar boiled
to a dark colour, and empyreumatic flavour. Broom tops, wormwood, and other
plants, were formerly used to render beer fit for keeping, before hops were intro
into this country, but are now prohibited to be used in beer made for sale."

present law of this country, nothing is allowed to enter into the com-
eer, except malt and hops. Quassia and wormwood are often fraudulently
both of which are easily discoverable by their nauseous bitter taste.
beer which does not preserve so well as hop beer. Sulphate of iron,
lt, are often added by the publicans, under the name of *beer-heading*, to
thing property to beer, when it is poured out of one vessel into another.
d extract of gentian root are added with the same view. Capsicum,
adise, ginger root, coriander seed, and orange peel, are also employed to
y and flavour to weak or bad beer. The following is a list of some of the
stances seized at different breweries, and brewers' druggists' laboratories,
s copied from the Minutes of a Committee of the House of Commons;
icus multum (an extract of the cocculus), colouring, honey, hartshorn
anish juice, orange-powder, ginger, grains of paradise, quassia, liquorice,
ds, copperas, capsicum, mixed drugs. Sulphuric acid is frequently added
forward, or make it hard, giving to new beer instantly the taste of what
nonths old."

ars at first sight, a rather formidable picture of adulteration: nevertheless
articles enumerated are perfectly harmless, and of those which are really
e use appears to have very much declined, partly perhaps in consequence
ved taste of consumers. Formerly there was a preference for what was
ard beer, that is to say beer in which nearly all the sugar and mucilage
onverted into alcohol by fermentation: hence the use of sulphuric acid,
ated, to simulate the taste of beer thus advanced in fermentation.
l to burnt sugar or treacle, which is added to porter to give colour and
e is now legalised, and therefore it can no longer be regarded as an
.

d and *cocculus indicus* are sometimes added to give bitterness to beer,
bitter ale. The latter of these substances is especially objectionable, as
very poisonous substance, viz. picrotoxin. Picric acid may be detected
Lassaigne, by treating the liquid, evaporated to half or a quarter of its
ubacetate of lead, or shaking it up with powdered animal charcoal. Pure
eby almost wholly decolorised; but if picric acid is present, the filtered
s a lemon-yellow colour. This reaction is very delicate, sufficing to detect
cric acid in 12,000 to 18,000 parts of beer. Subacetate of lead likewise
the bitter principle of the hop, and thereby deprives pure beer of its
but beer containing picric acid remains bitter after being thus treated.
o Pohl (Wien. Akad. Ber. xii. 88), a still more delicate test for picric
ined by immersing unbleached sheep's wool, or any fabric made there-
beer, boiling for six or ten minutes, and then washing the wool. If
pure, the wool remains white, but if picric acid is present, even to the
nly 1 pt. in 125,000, the wool then appears of a canary-yellow colour, pale
rding to the quantity.

n may be detected, according to T. J. Herapath, by mixing the beer with
tate of lead; removing the lead from the filtrate by sulphuretted hydrogen;
in, boiling for a few minutes; then slowly evaporating the solution till it
ckish; shaking it up with pure animal charcoal; collecting the charcoal,
ins the picrotoxin, on a filter; washing it with the smallest possible
water; then drying it at 100° C.; boiling it with alcohol; concentrating
filtrate; and leaving it to evaporate. The picrotoxin then separates in
l quadrilateral prisms; or if the solution be rapidly concentrated, in
athery tufts. (For figures of these crystals, see *Muspratt's Chemistry*,

substances added to beer will be found in the ash. Chalk is sometimes
r beer to neutralise the acid; in that case, the ash will contain more lime
rmal quantity. If copperas has been added to promote the *heading*, the
give the reaction of sulphuric acid with chloride of barium, and the ash
an abnormal quantity of oxide of iron.

'S VOLATILE SPIRIT, *Spiritus sulphuris Beguini*, consists essen-
phide of ammonium with excess of sulphur.

DONNA, OIL OF. An oil expressed in Wurtemberg from the seed of
shade (*Atropa belladonna*), and used for illumination and for culinary pur-
impid, of golden-yellow colour, of insipid taste, and without odour. Sp. gr.
° C. It thickens at − 16° C. and solidifies at − 25°. The vapours which
uring the process of extraction, intoxicate the workmen. The narcotic
the plant is retained in the marc, which cannot therefore be used as food
(Gerh. ii. 881.)

BELLADONNINE. An alkaloïd said to exist in *Atropa belladonna.*

BELL-METAL ORE. See Tin Pyrites.

BELMONTIN. A fatty substance prepared from Burmese naphtha.

BELONITE. Kobell's name for Needle-Ore.

BEN, OIL OF. The oil expressed from the fruits of *Moringa Nux Behen,*
Guilandina moringa Linn.; or *Moringa oleifera* Lam. It is colourless or sl
yellow, of specific gravity 0·912, thick at 15° C., solid in winter. It is odourles
has a mild taste, is neutral to test-paper, and does not readily become rancid.
used in perfumery to extract the odorous principle of fragrant plants. In Indi
used as an embrocation for rheumatism. According to Völcker (Ann. Ch. P
lxiv. 342), it is saponified perfectly by potash, 400 grammes yielding abo
grammes of a mixture of solid fatty acids, together with oleic acid. The solid
acids are: 1. An acid soluble in strong alcohol, insoluble in ordinary alcohol, m
at 83° C. and containing 81·6 per cent. carbon and 13·8 hydrogen, numbers
approximate to the formula $C^{45}H^{90}O^2$; but the quantity obtained was too sm
complete investigation.—2. Ordinary margaric acid.—3. An acid resembling
acid, and called by Völcker, *benic acid.*

Another kind of oil of ben, said to be obtained from the seeds of *Moringa*
yields by saponification four fixed fatty acids, viz. stearic acid, margaric acid, a
peculiar acids, *benic acid* and *moringic acid.* (Walter, Compt. rend. xxii. 114

BENIC ACID. This name has been applied to two different fatty acids
tioned in the last article, both obtained from oil of ben, the one by Völcker, th
by Walter. For distinction, Völcker's acid, which has the higher melting poin
be called *benostearic acid,* and Walter's *benomargaric acid.*

Benomargaric Acid, $C^{15}H^{30}O^2$, crystallises from its alcoholic solution in very
nodules, melting at 52° or 53° C.

Benomargarate of ethyl is very soluble in alcohol, and separates from the s
in a crystalline mass. It melts at a very low temperature, even at the heat
hand. (Walter.)

Benostearic Acid, $C^{21}H^{42}O^2$ according to Völcker, $C^{22}H^{44}O^2$ according to Str
(Ann. Ch. Pharm. lxiv. 346).—The latter formula agrees with Völcker's analysis
than the former. It is a white crystalline fat, melting at 76° C. and solidify
70° C. to a shining white crystalline mass, composed of needles, which may be
to powder; it is soluble in alcohol, and bears a strong resemblance to stearic acid.

Benostearate of sodium, $C^{22}H^{43}NaO^2$, is obtained by saponifying the acid wi
bonate of sodium, and dissolving the dried soap in absolute alcohol. The al
solution solidifies after a while to a gelatinous pulp, which is resolved into cry
grains by drenching it with a large quantity of alcohol. The *barium*-salt, $C^{44}H$
is precipitated on mixing an alcoholic solution of the sodium-salt with chlo
barium. The *lead*-salt, $C^{44}H^{86}Pb''O^4$, is a white precipitate obtained by mixi
soda soap with acetate of lead.

Benostearate of ethyl, $C^{22}H^{43}O^2.C^2H^5$, is obtained by passing hydrochloric ac
through a solution of the acid in absolute alcohol. It is a crystalline mass, mel
48° or 49° C. (Völcker.)

BENZALDIDE. Syn. with hydride of benzoyl. See Benzoyl, Hydride

BENZAMIC ACID. Syn. with Oxybenzamic Acid (*q. v.*)

BENZAMIDE. $C^7H^7NO = N.C^7H^5O.H^2$.—*Nitride of Benzoyl* and *Hy*
Liebig and Wöhler, Ann. Ch. Pharm. iii. 268; Fehling, *ibid.* xxviii. 48; Sch
ibid. lxxv. 195; Laurent, Rev. Scient. xvi. 391; Gerhardt, Traité, iii. lxxv.

This body may be obtained in various ways. 1. By the action of ammonia o
mide, chloride, or cyanide of benzoyl. Chloride of benzoyl, when saturated wi
fectly dry ammonia, evolves heat and solidifies into a white mass of benzamid
chloride of ammonium, which must be repeatedly broken up, lest any chloride o
zoyl be enclosed in it, and so escape the action of the ammonia. The sal-ammo
extracted with cold water, and the benzamide crystallised from boiling water.
hardt prefers pounding chloride of benzoyl in a mortar, with excess of commerci
bonate of ammonium, heating the whole gently, extracting with cold wate
crystallising the residue from alcohol or boiling water. Laurent prepares it by
an alcoholic solution of chloride of benzoyl with aqueous ammonia.—2. By the
of ammonia on benzoic anhydride.—3. By the action of ammonia on benzoate of
The reaction takes place slowly at the ordinary temperature, more rapidly whe
ether is heated with aqueous ammonia over 100° C. in a sealed tube (Dumas).—
boiling hippuric acid with water and peroxide of lead (Schwarz, Fehling);
heating it in a stream of dry hydrochloric acid. (Strecker.)

hot aqueous solution is cooled suddenly, benzamide separates in small
s, resembling those of potassic chlorate. When it is cooled slowly, it
a mass of white shining needles, in which cavities form after a time, con-
more large crystals; the transformation extends gradually through the
The finest crystals are obtained from a solution containing a little
nonia. The crystals belong to the trimetric system. Benzamide is in-
st insoluble in cold water, soluble in hot water (especially if it contains
alcohol, and in ether. It melts at 115° C., and solidifies on cooling to a
ass; between 286° and 290° it volatilises undecomposed; its vapour
of bitter almonds, owing to the formation of some benzonitrile, is very
and burns with a smoky flame.
ur of benzamide is passed through a red-hot tube, it is but slightly de-
nall portion of a sweetish oil being formed, which, according to Gerhardt,
. It is decomposed at a moderate heat, when passed through a tube
umice-stone, yielding hydrogen, nitrogen, carbonic oxide, and benzol
Benzamide is not decomposed by cold caustic potash; but on boiling,
oate is formed, and ammonia evolved. It is similarly decomposed by
trong acids, the solution on cooling depositing benzoic acid, while it re-
onium-salt of the acid employed. When baryta is heated with benza-
rgoes a kind of fusion, and appears to be converted into hydrate of
onia is evolved, together with the oil which Gerhardt regards as benzo-
amide, heated with potassium, yields cyanide of potassium and benzo-
de of phenyl), but no ammonia. Heated with benzoic anhydride, or
nzoyl, it yields benzonitrile and benzoic acid:

$$C^7H^7NO + \underset{\text{Benz. anhyd.}}{C^{14}H^{10}O^3} = \underset{\text{Benz. acid.}}{2C^7H^6O^2} + \underset{\text{Benzonitrile.}}{C^7H^5N}$$

$$C^7H^7NO + C^7H^5O.Cl = C^7H^6O^2 + C^7H^5N + HCl$$

s also formed when benzamide is heated alone, or in a stream of dry
cid (Handw.); or treated with phosphoric anhydride or pentachloride of
Benzamide is not decomposed by boiling with water and peroxide of
ydrochloric or sulphuric acid be added, and the whole boiled, filtered,
nmonia, and exposed to the air, it turns brown, and deposits a mould-

amide is gently heated with fuming hydrochloric acid, it dissolves, con-
he acid, and forming *hydrochlorate of benzamide*, $C^7H^7NO.HCl$, which
ooling in long aggregated prisms. It is a very unstable compound; the
off hydrochloric acid when exposed to the air, and in a few days have
e, and lost the whole of their acid. (Dessaignes, Ann. Ch. Phys. [3]

is a primary amide, *i. e.* it represents 1 at. NH^3 in which 1H is replaced
The remaining 2H may be wholly or partially replaced by a metal, or
id or basic radicle, secondary or tertiary amides or alkalamides being
se alkalamides which contain organic radicles are described under the
amine; the amides and those of the alkalamides which contain a metal
bed here.

rcuramide. $C^{14}H^{12}Hg''N^2O^2 = (N.C^7H^5O.H)^2Hg''$ (Dessaignes,
oc. cit.).—Aqueous benzamide dissolves mercuric oxide abundantly, and
solution solidifies to a crystalline mass, which is coloured with excess of
s treated with hot alcohol, and the solution on cooling deposits benzo-
in white shining laminæ, which may be washed and dried at 100° C. It
ble in alcohol and boiling ether. It is violently attacked by chloride of
ing benzoic acid, benzonitrile, and chloride of mercury.
nzamide also dissolves small quantities of cupric and argentic oxides;
ounds have not been examined.

sulphophenamide. $C^{15}H^{13}NSO^4 = N.C^7H^5O.C^2H^3O.C^6H^5SO^2$.—Pro-
action of chloride of acetyl on benzosulphophenylargentamide.

ylsulphophenamide, $C^{23}H^{21}NSO^4 = N.C^7H^5O.C^{10}H^{11}O.C^6H^5SO^2$, is
e action of chloride of cumyl on benzosulphophenargentamide; it crys-
ther in confused prisms.

cylimide. $C^{14}H^9NO^2 = N.C^7H^5O.C^7H^4O''$ (Limpricht, Ann. Ch.
250).—Obtained by heating benzosalicylamic acid (benzosalicylamide) in
to 270° C., until about ⅓ has volatilised, and boiling the residue with
es of alcohol, to remove the undecomposed acid. The pulverulent benzo-
dissolved in a larger quantity of boiling alcohol, whence it separates on
ll yellowish needles. It is soluble in about 1000 pts. boiling alcohol.

Benzosulphophenamide. $C^{13}H^{11}NSO^3 = N.C^7H^5O.C^6H^5SO^2.H$ (Gerhardt
Chiozza, Ann. Ch. Phys. [3] xlvi. 145).—Obtained by heating equivalent quan
of chloride of benzoyl and sulphophenamide to 140°—145° C., as long as hydroch
acid is evolved. The fluid mass crystallises on cooling, and is recrystallised
boiling alcohol. Forms shining, colourless, truncated, interlaced needles, whic
slightly soluble in cold water or ether, readily in alcohol. It has a strong acid
tion, and is readily soluble in caustic alkalis. It melts between 135° and 140
when quickly heated, it burns, gives off vapours of benzonitrile, and no longer soli
on cooling. Its ammoniacal solution becomes syrupy when gently evaporated
finally solidifies into a radiated mass, which Gerhardt states to be the acid ammo
salt of *benzosulphophenamic acid*, $C^{26}H^{23}N^3S^2O^8 = NH^3.(C^{13}H^{13}NSO^4)^2$. This s
very soluble in water and alcohol, but insoluble in ether. When an acid is
to its aqueous solution, an oily substance separates, which soon changes into n
of benzosulphenamide.

Benzosulphophenamide, like many other amides, behaves like a hydrate when
on by pentachloride of phosphorus, forming the chloride of a peculiar body,
Gerhardt calls *benzosulphophenamidyl.*

$$C^{13}H^{11}NSO^3 + PCl^5 = \underset{\text{Chloride of benzo-sulphophenamidyl.}}{C^{13}H^{10}NSO^2.Cl} + PCl^3O + HCl.$$

The reaction does not take place till heat is applied. The new compound is d
posed by heat into benzonitrile and chloride of sulphophenyl. When it is
rated with carbonate of ammonium it forms an amide, *benzosulphophenamidyla*
$N.C^{13}H^{10}NSO^2.H^2$, which crystallises from alcohol, and is very slightly solu
ammonia. (Gerhardt, cited in Handw. ii. [1] 884.)

Benzosulphophenargentamide. $C^{13}H^{10}AgNSO^3 = N.C^7H^5O.C^6H^5SO^2.Ag.$—
nitrate of silver is added to a boiling aqueous solution of benzosulphophenamid
taining a little ammonia, there is no precipitate; but on cooling, this compound sep
out in colourless needles. It is but slightly soluble in cold water, readily in al
It is decomposed by heat, giving off sulphurous anhydride and benzonitrile, and le
a residue of metallic silver and carbon. Its solution in strong ammonia yields o
poration, fine rose-coloured crystals, which contain the elements of 1 at. benzos
phenamide + 1 at. ammonia. They are readily soluble in boiling water; the so
on boiling deposits crystals of benzosulphophenargentamide; the addition of a
separates benzosulphophenamide. Gerhardt regards this compound as a di
$N^2.C^7H^5O.C^6H^5SO^2.Ag.H^3$, a view which the absence of a diatomic radicle r
improbable.

Benzosulphophenylsodamide. $C^{13}H^{10}NaNSO^3 = N.C^7H^5O.C^6H^5SO^2.Na.$—
zosulphophenamide dissolves in sodic carbonate with evolution of carbonic anhy
the solution is evaporated to dryness, and the residue exhausted with boiling al
which deposits the compound on cooling in opaque nodules. It is soluble in
acids separate from it benzosulphophenamide. (Gerhardt, cited in Hand
[1] 884.)

Dibenzosulphophenamide. $C^{20}H^{15}NSO^4 = N.(C^7H^5O)^2.C^6H^5SO.$ (Ger
and Chiozza, *loc. cit.*)—Obtained by the action of chloride of benzoyl on benzos
phenargentamide. Chloride of silver is formed, together with a viscid mass,
dissolves in ether, and crystallises in large brilliant prisms. It melts at 105° C
is slightly soluble in ammonia. It cannot be obtained by the action of chlor
benzoyl on benzosulphophenamide.

Benzoyl enters into the composition of certain biamides and triamides, fo
compounds, which will be described under the original diamides and tria
referred to.

Substitution-products of Benzamide.

Bromobenzamide is not known.—Benzamide dissolves in bromine, withou
lution of hydrobromic acid; the solution, after some days, deposits deep-red cr
having the composition $C^7H^7NOBr^2$, which may be regarded as the hydrobrom
bromobenzamide, $C^7H^6BrNO.HBr$. The crystals are decomposed slowly by wate
mediately by ammonia, with separation of benzamide. (Laurent.)

Chlorobenzamide. $C^7H^6ClNO = N.C^7H^4ClO.H^2$ (Limpricht and U
Ann. Ch. Pharm. cii. 263).—Obtained by dissolving chloride of chlorobenzo
strong aqueous ammonia; the solution deposits yellow laminæ of chlorobenza
which are purified by recrystallisation from hot water or alcohol. It is insolu
cold water; it fuses at 122° C., and sublimes in small quantities. The compou
tained by Gerhardt and Drion (Ann. Ch. Phys. [3] xlv. 102), by tritu
chloride of chlorobenzoyl with carbonate of ammonium, has the same composition

t differs from it slightly in properties, being insoluble in water, soluble ammonia, whence it crystallises in fine needles. It evolves ammonia vith potash.

ramide. $C^7H^6N^2O^3 = N.C^7H^4(NO^2)O.H^2$. (Field, Ann. Ch. Pharm. ancel, Compt. Chim. 1849, 180.)—Obtained in small quantity by fusing of ammonium. Better, by adding aqueous ammonia to a solution of ether in a rather large quantity of alcohol, and allowing the mixture to ne days till it is not rendered turbid by water. It is then evapowater-bath till it crystallises on cooling; and the crystals are purified sation from mixed alcohol and ether. It is also formed by the action on chloride of nitrobenzoyl. Nitrobenzamide is slightly soluble in in hot water; also in alcohol, ether, or wood-spirit. From these ns it crystallises in long needles, or, by slow evaporation, in large tables ypsum. It fuses above 100° C., and crystallises on cooling. When boiled potash, it forms potassic nitrobenzoate. Its aqueous solution is decomhide of ammonium, as follows:

$$C^7H^6N^2O^3 + 3H^2S = \underset{\substack{\text{Phenyl-}\\\text{carbamide.}\\\text{(Phenyl-urea.)}}}{C^7H^8N^2O} + 2H^2O + S^3$$

nzamide. $C^7H^5N^3O^5 = N.C^7H^3(NO^2)^2O.H^2$ (Voit, Ann. Ch. Pharm. -When dinitrobenzoic ether is digested for some days with alcoholic orms a blood-red solution, which deposits dinitrobenzamide in yellowish risms. It has a bitter taste, and dissolves sparingly in cold, more readily ; the solution is neutral. It melts at 183° C., and is decomposed by Its ammoniacal solution is not precipitated by nitrate of silver.

ramide. Schwefelbenzamid. Benzamide sulfuré. $C^7H^7NS = N.C^7H^5S.H^2$ ompt. rend. xxvii. 329).—When a solution of benzonitrile in slightly alcohol is saturated with sulphuretted hydrogen, the liquid becomes ow; and if, after some hours, it is boiled down to ¼ its volume, and it deposits yellow flakes, which dissolve in boiling water, and separate long yellow silky needles of thiobenzamide. It is decomposed by meryielding mercuric sulphide, water, and benzonitrile; by potassium, sic sulphide and cyanide. F. T. C.

NIL. $C^{28}H^{26}N^2O^2$ (?) (Laurent, Rev. scient. xix. 446.)—Crude oil, shaken up with potash, is distilled till about ⅓ has passed due dissolved in ether-alcohol, and ammonia passed into the solution. which forms is separated and boiled with a large quantity of ether; and n cooling deposits silky crystals and a white powder: the latter is bennearly insoluble in alcohol, difficultly soluble in ether. It melts at 170° C., very slowly. On dry distillation, it yields a substance soluble in ether. alcoholic potash, and the solution, on cooling, deposits crystals which examined. F. T. C.

NILIDE. Syn. with Phenylbenzamide. See PHENYLAMINE.

E or BENZOL. C^6H^6, or $C^{12}H^6$.—*Benzine, Hydride of phenyl, Bicarburet* (Faraday, Phil. Trans. 1825, 440. Mitscherlich, Ann. Ch. Pharm. got, Ann. Ch. Phys. [2] lvi. 59. Mansfield, Chem. Soc. Qu. J. i. 244.) by Faraday. It is a product of the decomposition of many organic com- formed: 1. When benzoic acid is heated with caustic lime or baryta ich), or when its vapour is passed over red-hot iron (Darcet, Ann. 2] lxvi. 99).—2. When phtalic acid is heated with caustic lime Ann. Ch. Pharm. xlii. 217), or insolinic acid with baryta (Hof- By dry distillation of quinic acid (Wöhler).—4. By passing vapour oil over red-hot lime (Ohme, Ann. Ch. Pharm. xxxi. 318).—5. By through red-hot tubes (Faraday).—6. By dry distillation of coal Mansfield).—7. In small quantity, when acetic acid or alcohol is gh a red-hot tube (Berthelot, Compt. rend. xxxiii. 210). It is also goon tar. (De La Rue and Müller.)

st method of preparing pure benzene, is to distil 1 pt. benzoic acid with lime at a gently increasing heat; the mixture of benzene and water which is shaken up with a little potash, the benzene decanted, dried over alcium, and rectified on the water-bath. 3 pts. benzoic acid yield 1 pt. e most abundant source of benzene is coal-tar; but the product obtained urce is very impure, containing several higher hydrocarbons, volatile d other substances. To obtain benzene pure, Mansfield shakes up the

light oil obtained by the distillation of coal-tar with dilute sulphuric acid, th
water, and then with potash, in order to remove all the acids and alkaloids
contains, and submits the washed oil to repeated fractional distillation; the
which passes over at 80°—90° C. is cooled to −12°, when the benzene cry
and is purified from liquid substances by pressure. A better method is t
the washed light oil in a metal still, and to pass the vapour upwards through
surrounded with boiling water, and then into a cooled receiver; thus the oil
boil above 100° C. are condensed and run back into the still. The dist
similarly treated, the water round the condensing-tube being kept at 80° C.
distillation stopped when the heat in the retort rises to 90°. This second di
(only half of which solidifies at 20°), is shaken up with $\frac{1}{10}$ vol. strong nitric a
canted, and shaken up with $\frac{1}{2}$ vol. strong sulphuric acid, rectified without deca
and the product purified as before by cooling and pressure. Commercial be
always very impure, containing many higher hydrocarbons; it may be approx
purified by distillation in the water-bath.

At the ordinary temperature, benzene is a limpid, colourless, strongly re
oil, of specific gravity 0·85 at 15°·5 C. (**Faraday, Mitscherlich**), 0·899
(**Kopp**). When cooled, it solidifies into fern-like tufts, or into hard mas
camphor, which melt at 5°·5 C., expanding in bulk at the same time, and
again at 0°. At −18°, it is hard, brittle, and of specific gravity 0·956. It
80°·4 at 776 m'm. (**Kopp**), at 86° (**Mitscherlich**), and volatilises undeco
Its vapour-density is (expt.), 2·77 (calc.), 2·704. It has a pleasant smell
scarcely soluble in water, but imparts a strong odour to it; readily soluble in
ether, wood-spirit, and acetone. It dissolves sulphur, phosphorus, and iodin
cially on heating; fixed and volatile oils, camphor, wax, mastic, caoutcho
gutta-percha, abundantly; gum-lac, copal, anime, and gamboge, in small qu
quinine, somewhat readily; strychnine and morphine in small quantity; cin
not at all (**Mansfield**). Impure benzene is much used to remove stai
silk, &c.

Benzene is very inflammable, and burns with a bright smoky flame. A mi
1 vol. benzene with 2 vols. alcohol of 0·85, forms a very good lamp-oil; a lar
portion of benzene gives a smoky flame. When vapour of benzene is passed
a red-hot tube, carbon is separated, and a gaseous hydrocarbon formed. *Chl*
bromine (not *iodine*), act upon it in the sunshine, forming substitution-produ
below). Strong *nitric acid* converts it into nitrobenzene; according to Abel, t
result is obtained by repeated distillation with dilute acid. *Sulphuric anhy*
fuming sulphuric acid converts it into sulphobenzide and sulphophenylic acid
non-fuming sulphuric acid into the latter product only (**Gerhardt**). Acco
Mansfield and Mitscherlich, the non-fuming acid has no action upon it. *Po*
aqueous alkalis, and *perchloride of phosphorus*, do not act upon benzene, eve
heated to its boiling point; neither does aqueous chromic acid (**Abel**), or p
gas in sunshine. (**Mitscherlich.**)

Church (Phil. Mag. [4] xiii. 415) describes, under the name of *Parabe*
hydrocarbon obtained by him from the light oil of coal-tar, which is isome
benzene, but has a different smell, boils at 97°·5 C. and does not solidify
Nitric acid converts it into nitrobenzene; fuming sulphuric acid into an acid
with sulphophenylic acid, but whose copper- and barium-salts are somewhat
in properties from those of that acid.

Hofmann (Ann. Ch. Pharm. lv. 201) gives a good process for the det
benzene in a mixture of volatile oils, founded on the facility with which be
converted into nitrobenzene by nitric acid, and nitrobenzene into phenyla
reducing agents. The liquid to be examined is warmed in a test-tube with fumi
acid, diluted with water, and shaken up with ether, which dissolves the nitro
The ethereal solution is separated by a pipette, and mixed with equal vol
alcohol and hydrochloric acid, and granulated zinc added. After five min
mixture is saturated with potash, again shaken up with ether, which disso
liberated phenylamine, and the ethereal solution evaporated on a watch-gl
addition of a drop of hypochlorite of calcium to the residue gives the intens
colour characteristic of phenylamine.

Substitution-products of Benzene.

Bromine dissolves in benzene, forming compounds in which 1, 2, and 3 at
respectively replaced by Br.

Bromobenzene. *Monobromobenzid. Bromide of phenyl*, C^6H^5Br (C
Ann. Ch. Phys. [3] lii. 309).—The vapour of an equivalent quantity of bro
passed into a large flask in which some benzene is heated to boiling; the pr

h potash, dried, and distilled; most of it passes over about 150° C. It is a
iquid, smelling like benzene; it does not solidify at −20° C.; its vapour-
5·631. It is not decomposed when heated to 200° C. with acetate of silver, or
tion of sulphate of silver in strong sulphuric acid. Heated with potassium
tube, it explodes; with sodium, it yields benzene and a crystalline body.
ric acid converts it into *bromonitrobenzene*, $C^6H^4BrNO^2$, a crystalline body
s below 90°, and distils undecomposed. Fuming sulphuric acid dissolves it,
omosulphophenylic acid.

obenzene. *Bibromobenzid.* $C^6H^4Br^2$ (Couper, *loc. cit.*)—When mono-
ene is acted on for some time by excess of bromine, hydrobromic acid is
d crystals separate, which, by recrystallisation from ether, are obtained in
e prisms, which melt at 89° C. and boil at 219° without decomposition.

nobenzene. *Terbromobenzid.* $C^6H^3Br^3$ (Mitscherlich (1835), Pogg.
374. Lassaigne, Rev. scient. v. 360).—A mixture of benzene and bromine
sunlight gradually forms a solid crystalline body, which is purified by
th boiling ether. This is the *hydrobromate of tribromobenzene*, $C^6H^6Br^6$ =
HBr. It forms a white inodorous tasteless powder, insoluble in water,
oluble in boiling alcohol or ether, whence it crystallises in microscopic
mbic prisms. It is fusible, and crystallises on cooling. When heated, it
imes undecomposed, and is partly resolved into tribromobenzene, hydro-
l, bromine, and hydrogen Heated with hydrate of calcium, it yields *tri-*
ne. This compound is best obtained by boiling the hydrobromate with
otash, adding water, dissolving the precipitated oil in ether, and evaporating
n; it forms silky, very fusible needles, soluble in alcohol and ether, and
hout decomposition.

lorobenzene. See PHENYL, CHLORIDE OF.

robenzene. *Chlorobenzid.* $C^6H^3Cl^3$ (Mitscherlich, *loc. cit.* Péligot,
hys. [2] lvi. 66. Laurent, *ibid.* lxiii. 27).—The action of chlorine in
pon benzene is similar to that of bromine, resulting in the formation of
hydrochlorate of trichlorobenzene, $C^6H^6Cl^6 = C^6H^3Cl^3.3HCl$, which are
h ether or recrystallised from boiling alcohol. It forms colourless shining
rhombic prisms with truncated lateral edges, insoluble in water, soluble in
ther: melts at 132° C. (Mitscherlich); 135°—140° (Laurent); distils
at 288°, with partial decomposition, without leaving any residue. In its
ions, it resembles the corresponding bromine compound. *Trichlorobenzene*
by the repeated distillation of the hydrochlorate alone (Mitscherlich);
ing it with hydrate of barium or calcium, washing the distillate with water,
ing it over chloride of calcium; or by boiling it with alcoholic potash
). It is a colourless oil, of specific gravity 1·457 at 7° C.; boils at 210°;
sity 6·37; insoluble in water, soluble in alcohol, ether, or benzene. It is
d by chlorine, bromine, acids, or alkalis.

dinitrobenzene. See CHLORIDE OF DINITROPHENYL, under PHENYL,
OF.

enzene. *Nitrobenzol.* *Nitrobenzid.* $C^6H^5NO^2$ (Mitscherlich (1834),
xxxi. 625).—Formed by the action of fuming nitric acid on benzene, or by
tillation of nitrobenzoates. Prepared by gradually adding benzene to warm
ic acid; the nitrobenzene separates as an oil on cooling, is washed with
rectified over chloride of calcium. It is a yellowish liquid, with a very
e, and a smell like bitter-almond oil; specific gravity 1·1866 at 14°·4 C.
oils at 213° C. (Mitscherlich), 219°—220° (Kopp); vapour-density 4·4.
C. it crystallises in needles. It is insoluble in water, readily soluble in
l ether. It is much used by perfumers, under the name of *Essence de mir-*
s not attacked either by chlorine or bromine at the ordinary temperature;
our is decomposed when passed with chlorine through a red-hot tube, yield-
hloric acid. Fuming nitric acid dissolves it, and on heating converts it
obenzene. Strong sulphuric acid dissolves it, and on heating decomposes
a dark-coloured solution, and evolving sulphurous anhydride. Dilute
lphuric acid does not attack it, even at 100° C. It is scarcely attacked by
h aqueous potash or ammonia, or by distillation over caustic lime; when
alcoholic potash, it yields azoxybenzide (p. 479); and when distilled with
otash, azobenzide. When a solution of nitrobenzene in alcohol is mixed
nia, and saturated with sulphuretted hydrogen, sulphur is deposited, and the
hen cooled to 0° C., solidifies to a mass of yellow needles, which are soluble
alcohol and have a biting taste; on driving off the alcohol by heat, more
deposited, and phenylamine is finally left:

$$C^6H^5NO^2 + 3H^2S = C^6H^7N + 2H^2O + S^3.$$

Other reducing agents, *e.g.* zinc with a mixture of alcohol and hydrochlori iron filings and acetic acid, and arsenite of potassium, convert nitrobenzer phenylamine.

Dinitrobenzene. $C^6H^4N^2O^4 = C^6H^4(NO^2)^2$ (Deville (1841), Ann. Ch [3] iii. 187. Muspratt and Hofmann, Ann. Ch. Pharm. lvii. 214).—Form slowly by boiling nitrobenzene with fuming nitric acid; rapidly when nitrobe dropped gradually into a mixture of equal vols. fuming nitric and strong su acid as long as solution takes place. The mixture is boiled for some minutes, crystalline magma which forms on cooling is washed with water and recrys from boiling alcohol. It forms long shining needles or laminæ, which melt 100° C. and solidify into a radiated mass. It is insoluble in water, soluble i alcohol. Sulphide of ammonium converts it into nitrophenylamine, and se sulphur. Zinc and hydrochloric acid convert it into nitrosophenylin (*q. v.*) ing to Hilkenkamp (Ann. Ch. Pharm xcv. 86), sulphite of ammonium c it into a peculiar acid, *dithiobenzolic* or *phenyldisulphodiamic acid*, $C^6H^8N^2S^2O$ obtained this compound by the action of sulphite of ammonium on nitroben follows; but he attributes its formation to the presence of dinitrobenzene. He 80 grms. nitrobenzene with 240 grms dry sulphite of ammonium, 1 litre absolute and some carbonate of ammonium, for 8 or 10 hours on a water-bath. The liq filtered from the sulphate of ammonium which separated on cooling, and evapor a syrup, when it deposited at first abundance of fine white laminæ, which decomposed, and then a smaller quantity of hard needles, which are the amm salt of this acid.

$$\underset{\text{Dinitrobenzene.}}{C^6H^4N^2O^4} + 6SO^3N^2H^8 = \underset{\text{Dithiobenzolic acid.}}{C^6H^8N^2S^2O^6} + 4SO^4N^2H^8 + 4NH^3.$$

It is readily soluble in water or dilute alcohol, slightly in absolute alcohol, in in ether. Nitric acid colours its solution yellow; chlorine forms with it abu of chloranil, with traces of a brown resinous substance. The barium-salt talline, soluble in water, insoluble in alcohol. The acid has not been obtained free state. F.

BENZHYDRAMIDE. *Hydride of Cyanazobenzoyl.* $C^{22}H^{18}N^2O$ (La Ann. Ch. Phys. [2] lxvi. 180; Laurent and Gerhardt, Compt. Chim. 185 —A product of the action of ammonia on crude bitter-almond oil; or of cy ammonium on hydride of benzoyl.

$$3C^7H^6O + NH^4CN = C^{22}H^{18}N^2O + 2H^2O.$$

Crude bitter-almond oil heated to 100° C., is saturated with dry ammonia, product dissolved in ether-alcohol: after twenty-four hours, the solution be deposit crystals, which go on increasing for three or four days. The mother-li decanted, and the crystals treated with boiling alcohol, which leaves a white *benzoylazotide.* The solution, on spontaneous evaporation, deposits small needles with drops of oil: these are washed quickly with a little ether-alcohol, and tallised from boiling alcohol. It is also formed in the process for the prepar azobenzoyl (*q. v.*)

Benzhydramide forms colourless, microscopic, rectangular prisms, with two t faces intersecting at an obtuse angle. It is insoluble in water, sparingly soluble alcohol, readily in hot alcohol or in ether. It is very fusible, and solidifies on to a resinous mass, without decomposition: when further heated, it gives off cyanic acid, and yields an oil, a crystalline sublimate, and a little carbon. It decomposed by cold dilute hydrochloric acid; but, on boiling, it yields hyd benzoyl, hydrocyanic acid, and chloride of ammonium. F.

BENZHYDROCYANIDE. Syn. with Benzimide (*q. v.*)

BENZHYDROL. BENZHYDROLIC ACID. Rochleder and Hlasiwe the name of benzhydrol to a camphor obtained by them from oil of cassia. F investigation by Rochleder and Schwarz, has shown that this camphor contai substances, one richer in hydrogen, the other in oxygen: they call the former *drol*, the latter, *benzhydrolic acid.* F.

BENZIDAM. Syn. with Phenylamine (*q. v.*)

BENZIDINE. $C^{12}H^{12}N^2 = N^2.C^{12}\overset{\prime\prime}{H}{}^8.H^4$ (Zinin, J. pr. Chem. xxxvi. 9 173; Ann. Ch. Pharm. lxxxv. 328.)—An organic alkali formed by the reduct azobenzene or azoxybenzene. It is obtained by saturating with sulphuretted hy a solution of azobenzene in alcoholic ammonia: the liquid turns brown, and, heated, deposits sulphur abundantly, which is filtered off. The filtrate, on c deposits crystals of benzidine, which are purified by dissolving them in boiling a te sulphuric acid as long as a precipitate forms, washing the precipitate with dissolving it in boiling aqueous ammonia: the solution, on cooling, deposits white shining scales. When an alcoholic solution of azobenzene or azoxyreated with sulphurous acid, sulphate of benzidine is at once precipitated. is inodorous; scarcely soluble in cold water, readily in hot water, alcohol, s solution has a bitter burning taste. It melts at 108° C., and cools to a nass: further heated, it partly sublimes, and is partly decomposed. When f benzidine, or its salts, is treated with chlorine, it becomes first blue, then , and deposits scarlet crystals, scarcely soluble in water, more readily in bably azobenzene). Nitrous fumes attack it violently at a gentle heat, it into azobenzene (**Noble**). It is decomposed by strong nitric acid.

combines with acids, forming definite salts, which are mostly readily e: their solutions are precipitated by caustic alkalis or alkaline carbonates. *chlorate*, $C^{12}H^{12}N^2.2HCl$, crystallises in white, pearly, rhombic prisms, water or alcohol, almost insoluble in ether. The *chloroplatinate* $HCl.PtCl^4$, is a yellow crystalline precipitate, obtained by adding tetrachloride to the aqueous or alcoholic solution of the foregoing salt. It is slightly ater, insoluble in alcohol or ether. When boiled with water (more readily l or ether), it is converted into a dark-violet powder. The *nitrate* forms prisms, soluble in water. The *acid oxalate*, $C^{12}H^{12}N^2.C^2O^4H^2$, forms , radiated needles, slightly soluble in water or alcohol. The *acid sulphate*, O^4H^2, separates as a dull white powder, when sulphuric acid is added to a enzidine: from a very dilute solution it separates in crystals. It is scarcely oiling water or alcohol. The *benzoate*, *acetate*, *tartrate*, and *phosphate* are ne. With mercuric chloride, benzidine forms a crystalline double-salt, ater and alcohol. F. T. C.

nzidine, $C^{16}H^{20}N^2 = N^2.C^{12}H^{8\prime\prime}.(C^2H^5)^2.H^2$.—The hydriodate of this base, $HI)^2$, or *iodide of diethyl-benzidammonium* $[N^2.(C^{12}H^8)''(C^2H^5)^2.H^4].I^2$, is crystals by digesting benzidine with alcohol and iodide of ethyl, in a at 100° C. for two hours. Treated with ammonia, it yields the free h unites with acids forming well crystallised salts. The chloroplatinate, tCl^4, is sparingly soluble. (**P. W. Hofmann**, Proc. Roy. Soc. x. 585; harm. cxv. 362.)

benzidine, $C^{20}H^{28}N^2 = N^2.(C^{12}H^8)''.(C^2H^5)^4$, is obtained as a hydriodate by diethylated base with iodide of ethyl. The free base melts at 83° C. ret 80°, and forms crystalline salts with acids. *Iodide* of ethyl acts but , but when treated with *iodide of methyl*, attacks it with energy, forming: f *Dimethyl-tetrethyl-benzidammonium*, $C^{22}H^{34}N^2I^2 = [N^2.(C^{12}H^8)''.(C^2H^5)^4$. This salt dissolves sparingly in alcohol, but easily in boiling water, rystallises in long beautiful needles. Its solution is not precipitated by ut yields with oxide of silver, a strongly alkaline solution containing the $\left.\begin{matrix}(C^{12}H^8)''(C^2H^5)^4(CH^3)^2\\ H^2\end{matrix}\right\}O^2$. This base unites readily with acids, forming crystalline salts. The *chloroplatinate*, $C^{22}H^{34}N^2Cl^2.PtCl^4$, is almost insolur, but dissolves sparingly in boiling hydrochloric acid, whence it crystallises n beautiful needles. (**P. W. Hofmann**, *loc. cit.*)

Sousoxide de Stilbèse, $C^{14}H^{10}O^2$. (**Laurent**. Ann. Ch. Phys. [2] lix. ig. Ann. Ch. Pharm. xxv. 25. **Zinin**, Ann. Ch. Pharm. xxxiv. 190. Compt. Chim. 1845. 308.)—Formed by the action of oxidising agents on aurent prepares it by passing chlorine over fused benzoin as long as hydrois evolved, and crystallising the product from hot alcohol. Zinin heats benzoin with 2 pts. concentrated nitric acid; the reaction is complete when rous fumes are evolved, and when the yellow oil which rises to the surface r. This oil solidifies to pure benzil on cooling.

lises by spontaneous evaporation of its alcoholic or ethereal solution in long x-sided prisms, which are commonly hollow. Observed faces, ∞P . oP . P. t smell or taste, insoluble in water, soluble in alcohol, ether, and warm suland reprecipitated from the last by water. It fuses between 90° and 92° C. s to a fibrous mass: at a higher temperature, it volatilises undecomposed. with a red sooty flame. It is not altered by boiling with nitric acid or s potash: but when boiled with alcoholic potash, it turns blue and forms l. With ammonia, an alcoholic solution of benzil forms various products, o the concentration and the duration of the reaction (see AZOBENZIL, BENZILIM, IMABENZIL). With sulphuretted hydrogen, it deposits sulphur, yellow oil, smelling of garlic: this oil is more readily obtained by disl with alcoholic sulphide of ammonium. With sulphide of ammonium, it

yields two or three different products, among which is *hydrobenzil* (*q. v.*) Fuse
potassium, it gives off violet vapours and leaves a carbonaceous residue.

Benzil is polymeric with the hypothetical radicle benzoyl, C^7H^5O.

Hydrocyanate of Benzil. $C^{16}H^{12}N^2O^2 = C^{14}H^{10}O^2,2HCy$ (Zinin).—When
is dissolved in boiling alcohol, and an equal weight of nearly anhydrous pruss
is added, the mixture gradually deposits white shining rhombic tables of hydroc
of benzil. This compound melts and decomposes when heated, leaving pure
It is not attacked when boiled with water or strong hydrochloric acid: when
with nitric acid or ammonia, it yields benzil. Its alcoholic solution gives with
of silver a precipitate of cyanide of silver, and benzil crystallises from the so
When its alcoholic solution is heated with mercuric oxide, mercury is reduced, a
smell of benzoic ether becomes distinctly perceptible. F. T

BENZILAM. $C^{14}H^9N$. (Laurent, Rev. scient. xix. 443.)—Formed, to
with imabenzil and benzilim, by the action of ammonia on benzil. It is be
pared by dissolving imabenzil or benzilim in sulphuric acid, and adding
when an oil separates out which speedily solidifies: this is washed with wat
a little alcohol, and crystallised from ether-alcohol. It forms colourless r
prisms readily soluble in alcohol or ether. It melts at 105° C.: if imperfectly
it quickly crystallises on cooling, but if perfectly fused, it solidifies much more
without crystallisation. It is volatile without decomposition. Boiling al
potash has no action upon it: nitric acid decomposes it, yielding an oil which c
lises on cooling, and is insoluble in ether: it is soluble in sulphuric acid, and is
cipitated by water. F. T

BENZILIC ACID. *Stilbic Acid.* $C^{14}H^{12}O^3$. (Liebig [1838], Ann. Ch.
xxv. 25. Zinin, *ibid.* xxxi. 329.)—Formed by the action of alkalis on be
benzoin. Benzil is dissolved in boiling alcoholic potash, in such quantity th
solution remains distinctly alkaline, and the whole is boiled until a sample of i
no turbidity when mixed with water. The solution is then evaporated to dry
the water-bath, the residue powdered, and exposed to an atmosphere of carbonic
dride till all the potash is converted into carbonate; it is then extracted with a
the solution mixed with water, and, after distilling off the alcohol, decolorise
animal charcoal, and evaporated to crystallisation. The potassic benzilate th
tained is redissolved in water, and mixed with boiling dilute hydrochloric ac
cooling, benzilic acid crystallises out.

It forms hard, shining, colourless needles, which are sparingly soluble in cold
readily in hot water, easily in alcohol or ether. It has no smell, a bitter r
taste, and a strong acid reaction. It melts at 120° C.; when heated more st
it turns red, and emits violet vapours which condense to a brown-red oily li
residue of carbon being left. This oil is volatile, insoluble in water, soluble
red colour in alcohol or ether: the solution is not decolorised by water, or by
chloric or sulphuric acid, but it is decolorised by potash, ammonia, or nitri
Benzilic acid burns with a very smoky flame. With strong sulphuric a
benzilates give a fine crimson colour, which is not easily destroyed by heat dis
on adding water, but reappears on evaporation. It dissolves in warm nitric ac
is precipitated unchanged by water. Pentachloride of phosphorus converts
chlorobenzil.

Benzilates.—Their general formula is $C^{14}H^{11}MO^3$. The *lead-salt* is obtai
adding the aqueous acid to neutral acetate of lead. It is a white powder, s
soluble in hot water: it is unalterable at 100° C., but when strongly heated me
red liquid, and emits violet vapours. The *potassium-salt* forms colourless, trans
anhydrous crystals, readily soluble in water and alcohol, insoluble in ether. I
at 200 °C., and solidifies on cooling: heated more strongly, it decomposes, yie
colourless oily distillate, smelling like naphthaline, insoluble in water, solu
alcohol; the residue contains carbon and potassic carbonate. The *silver-sa*
white, crystalline powder, obtained by precipitating nitrate of silver by the pot
salt. It is slightly soluble in hot water; at 100° C. it turns blue, without losing
and melts when further heated, emitting violet vapours and leaving metallic si
F. T

BENZILIM. *Benzilimide.* $C^{28}H^{22}N^2O^2$ (Laurent [1845], Rev. scient. xi
—One of the products of the action of ammonia on benzil. It is most easily o
pure by dissolving imabenzil in boiling alcoholic potash, and adding water
solution. It forms white, silky, very fine needles, sparingly soluble in alc
ether. It melts at 130° C. and solidifies slowly in cooling to an amorphous ma
distils apparently undecomposed, but the distillate is readily soluble in ethe
crystallises from it in needles. It is not attacked by boiling potash or by hydro
acid: warm nitric acid attacks it, evolving red fumes, and yielding a yellow oil

llises on cooling, and is insoluble in ammonia, but soluble and crystallisable ether. It dissolves in warm sulphuric acid, and the addition of water separates am. F. T. C.

NZIMIC ACID. (Laurent, Compt. Chim. i. 37.) — The name given by nt to a peculiar acid which is formed in the preparation of amarine (*q. v.*) It prepared by saturating an alcoholic solution of bitter-almond oil with ammonia, g it stand for 48 hours, and adding water, which takes up benzimate of ammo- The addition of hydrochloric acid to the aqueous solution precipitates the which is purified by dissolving it in alcohol containing ammonia, boiling the on, and neutralising with hydrochloric acid. It forms white silky needles, ble in water slightly soluble in alcohol: it melts when heated, and cannot be ed undecomposed. It has not been analysed. F. T. C.

NZIMIDE. *Benzhydrocyanide. Hydride of Cyanobenzoyl*, $C^{23}H^{18}N^2O^2$. rent (1836), Ann. Ch. Phys. [2] lix. 397: lxvi. 193; Rev. scient. x. 120. , Ann. Ch. Pharm. xxxiv. 188. Gregory *ibid.* liv. 372. Laurent and ardt, Compt. chim. 1850, 116.)—Formed by the action of hydrocyanic acid on le of benzoyl:

$$3C^7H^6O + 2CNH = C^{23}H^{18}N^2O^2 + H^2O.$$

de of benzoyl mixed with ½ its volume of nearly anhydrous prussic acid is up with an equal volume of strong alcoholic potash diluted with 6 pts. alcohol, e whole gently heated: after a time a white curdy precipitate separates, which led with water, and purified by solution in alcohol. Benzimide also occurs, with hydride of benzoyl and benzoin, in the resinous residue of the rectification of bitter-almonds: it may be extracted by treating the residue with hot alcohol. zimide forms a light loosely-coherent mass, white, with a greenish tinge, and a stain when rubbed or pressed. It is insoluble in water, or in cold potash or chloric acid; sparingly soluble in boiling alcohol or ether. When heated, it melts, ually volatilises with decomposition, leaving a carbonaceous residue. It dissolves ong sulphuric acid with a green colour, which soon changes to red, and is re- itated by water. Nitric acid dissolves it with decomposition: heated with nitric nd alcohol, it evolves red fumes and yields ammonia and benzoate of ethyl. with hydrochloric acid, it yields hydride of benzoyl, sal-ammoniac, and probably rmic acid.

$$C^{23}H^{18}N^2O^2 + 5H^2O = 3C^7H^6O + 2CH^2O^2 + 2NH^3.$$

d with strong bases, it yields benzene; and with potassic hydrate moistened with l, it forms ammonia and potassic benzoate. F. T. C.

NZINE. Syn. with BENZENE (*q. v.*)

NZOACETIC ANHYDRIDE. See ACETIC ANHYDRIDE.

NZOANGELIC ANHYDRIDE. See BENZOIC ANHYDRIDE.

NZOCARBOLIC ACID. BENZOATE OF PHENYL. See BENZOIC ACID.

NZOCHLORHYDRIN, $C^{10}H^{11}ClO^3$ (Berthelot, Ann. Ch. Phys. [3] xli. 302). of Berthelot's artificial fats, containing the elements of benzoic and hydrochloric and glycerin, minus water:

$$C^7H^6O^2 + HCl + C^3H^8O^3 = C^{10}H^{11}ClO^3 + 2H^2O.$$

prepared by saturating with hydrochloric acid gas a mixture of glycerin and c acid, which is kept for several hours at 100° C., and removing the excess of acid lic carbonate: the benzochlorhydrin then sinks to the bottom as an oily liquid. pure, it is a neutral oil, solidifying at −40°. It is decomposed by potash, ng potassic chloride and benzoate: and by hydrochloric acid and alcohol, yield- lycerine and benzoate of ethyl. The chlorine is not withdrawn from the und even by long digestion at 100° with oxide of silver. F. T. C.

NZOCINNAMIC ANHYDRIDE. See BENZOIC ANHYDRIDE.

NZOCUMINIC ANHYDRIDE. See BENZOIC ANHYDRIDE.

NZOCUMYLSULPHOPHENAMIDE. See BENZAMIDE.

NZOENE. Syn. with Toluol. See BENZYL, HYDRIDE OF.

NZOERETIC ACID. *Amorphous benzoic acid, Parabenzoic acid* (E. Kopp. . chim. 1849, 154).—An amorphous powder, obtained by heating gum-benzoin 6 or 8 pts. nitric acid, not strong enough to form nitrobenzoic acid. When pure, it is white; but it is commonly yellowish, owing to the presence of a small ty of a yellow resin, which accompanies it into all its compounds. It is readily in alcohol, ether, and boiling water. It has an aromatic, faintly sour and taste. It melts at 113° C., boils at 256°, and by dry distillation yields pure cry-

talline benzoic acid, and, if not quite pure, a slight carbonaceous residue.
gently heated, or exposed to the sun, it becomes covered with small cryst
benzoic acid. Distilled with lime, it yields benzene. It forms salts which cryst
with difficulty, and are generally less soluble than the corresponding benz
Different specimens have yielded different results to analysis: but in some cas
composition is very near that of benzoic acid. F T.

BENZOGLYCOLLIC ACID. $C^9H^8O^4 = (C^2H^2O)''.C^7H^5O.H.O^2$ (**Strecker**[
Ann. Ch. Pharm. lxviii. 54. **Strecker** and **Socoloff**, *ibid.* lxxx. 18. **Gössman**
xc. 181; xci. 359).—Formed by the action of nitrous anhydride on hippuric acid

$$2C^9H^9NO^3 + N^2O^3 = 2C^9H^8O^4 + N^4 + H^2O.$$

It is prepared by rubbing hippuric acid to a thin paste with strong nitric acid
passing a current of nitric oxide into the mixture: nitrogen is then evolved, an
hippuric acid gradually dissolved. After some time, the clear solution becomes o
from the deposition of benzoglycollic acid: the current of gas is kept up unt
liquid assumes a greenish colour, when a large quantity of water is added, and the
allowed to cool. The acid then separates out in considerable quantities; it is col
on a filter, washed with cold water, suspended in water, neutralised with milk of lim
the resulting calcium-salt is purified by recrystallisation and pressure between pape
subsequently decomposed by hydrochloric acid (**Socoloff** and **Strecker**). It ma
be prepared by slowly passing chlorine into a solution of hippuric acid in ex
moderately dilute potash: when the evolution of nitrogen ceases, the mixt
carefully neutralised by hydrochloric acid, concentrated by gentle evaporation
mixed with a slight excess of hydrochloric acid, when it solidifies to a crystalline
This is purified by solution in ether, and distilling off the ether from the watery
below it, when the acid separates as an oil in the midst of the water (**Göss**
The acid obtained by either of these methods generally contains a large qu
of benzoic acid, which is removed by partially neutralising the acid with m
lime and evaporating to dryness: benzoic acid, being the weaker acid of the
remains uncombined, and is extracted from the residue by ether.

Benzoglycollic acid crystallises from alcohol in colourless prisms of 37° 40
142° 20′, which often take the form of thin plates: when precipitated by acids
aqueous solutions of its salts, it separates as a white crystalline powder. It is sc
soluble in cold, more so in hot water, readily in alcohol and ether: it melts
water before dissolving. It melts when heated and solidifies to a crystalline
heated more strongly, it gives off vapours containing benzoic acid, and leaves a
residue of carbon. When boiled for some time with water, it is gradually decom
into benzoic and glycollic acids:

$$C^9H^8O^4 + H^2O = C^7H^6O^2 + C^2H^4O^3.$$

This decomposition is accelerated by the presence of a mineral acid.

BENZOGLYCOLLATES are mostly crystalline, soluble in water, some of them in a
also. They are neutral to litmus, and have a faint but peculiar taste. Their aq
solutions may be boiled and even evaporated to dryness without decomposition.
most of their solutions strong acids separate benzoglycollic acid as a crystalline po
The acid being monobasic, their general formula is $C^9H^7MO^4$.

The *Ammonium-salt* is obtained by saturating the acid with ammonia, or deco
ing the calcium-salt with ammonic carbonate. It loses ammonia when evaporate

The *Barium-salt*, $C^{18}H^{14}Ba''O^4 + 2Aq$, forms delicate silky needles, which lose
water at 100° C.

The *Calcium-salt*, $C^{18}H^{14}Ca''O^4 + 2Aq$, forms delicate silky needles, united in gr
which lose their water at 120° C. It dissolves in 42·3 pts. cold, and 7·54 pts. b
water. It possesses in a remarkable degree the property of forming supersatu
solutions, so that a solution saturated at boiling heat frequently takes some da
deposit all its crystals in successive crops. When a strong solution of this salt is
porated with chloride of calcium to a syrupy consistence, a double salt separate
on cooling in octahedrons, which are permanent in the air, but are decompose
water or alcohol into benzoglycollate and chloride of calcium.

The *Copper-salt* crystallises on cooling in abundant blue rhombic tables, wh
boiling saturated solution of the calcium-salt is mixed with nitrate of copper
becomes green and opaque at 100° C, but retains its lustre; is scarcely soluble in
more so in hot, water.

The *Ferric salt*, $2Fe^2O^3.3C^{18}H^{14}O^7 + 28Aq$, is a voluminous flesh-coloured pr
tate, insoluble in water, which becomes darker when dried. After drying in the
it loses 27·36 per cent. (28 at.) water at 100° C.

There appear to be at least two basic *Lead-salts* besides the normal one. Wh
cold solution of benzoglycollate of calcium is mixed with normal acetate of le

nt precipitate is formed, which is a mixture of several salts. If this be ed in cold water, the solution, on spontaneous evaporation, yields, first, crystals salt *b*, and subsequently soft starry crystals of the normal salt $C^9H^7PbO^4$, which ith partial decomposition at 100° C.

$C^{18}H^{14}Pb''O^4.Pb''O + 3Aq$, forms hemispherical groups of crystals, which melt °, and lose 1½ at. water.

$^{18}H^{14}Pb''O^4.5Pb''O + 2Aq$.—When the cold solution of the calcium-salt is mixed asic acetate of lead, and the precipitate digested in cold water and filtered, this ystallises after some days. It loses 1 at. water at 100° C.

precipitate obtained by adding the calcium-salt to a boiling solution of normal of lead, is a mixture of several basic salts.

Magnesium salt forms long, very slender needles, readily soluble in water and

Potassium- and *Sodium-salts* are obtained like the ammonium-salt. The former lises with difficulty, being very soluble. The latter crystallizes more readily hot saturated solution in rhombic tables; it contains 3Aq, which it loses at

Silver-salt, $C^9H^7AgO^4$, is obtained as a curdy precipitate when the neutral ium salt is mixed with nitrate of silver; this precipitate is washed in cold, and ed in boiling, water, whence it separates in white microscopic crystals, which moist quickly blacken in the light; when dry they are not changed at 100° C.

-salt, $C^{18}H^{14}Zn''O^4 + 4Aq$. A boiling saturated solution of the calcium-salt with chloride of zinc, yields on cooling long thin needles, which are dried by aper and recrystallised. They lose 2 at. water at 100° C. F. T. C.

ZOHELICIN. $C^{20}H^{20}O^8$. (Piria, Ann. Ch. Phys. [3] xxxiv. 278; xliv. 366.) product of the action of the nitric acid on populin. It may be regarded as ($C^{13}H^{17}O^7$), in which 1 H is replaced by benzoyl, $C^{20}H^{20}O^8 = C^{13}H^{15}(C^7H^5O)O^7$. populin (benzosalicin) as helicin is to salicin.

ined by dissolving populin in pure nitric acid of specific gravity 1·3, the solu- comes yellow, and benzohelicin soon crystallises out. On diluting the mother- with water, more crystals separate out. It forms silky needles closely resem- elicin. When boiled with water and magnesia, it is converted into helicin and acid. Synaptase has no action upon it. Acids and alkalis convert it into benzoic ydride of salicyl, and glucose:

$$C^{20}H^{20}O^8 + 2H^2O = C^7H^6O^2 + \underset{\text{Hydride salicyl.}}{C^7H^6O^2} + \underset{\text{Glucose.}}{C^6H^{12}O^6}.$$

F. T. C.

ZOIC ACID. *Flowers of Benzoin. Hydrate of Benzoyl. Benzoeblumen. saüre. Acide benzoïque.* $C^7H^6O^2 = C^7H^5O.H.O$. [or $C^{14}H^6O^4 = C^{14}H^5O.HO$.]

ory and Sources.—First noticed by Blaise de Vigenère (*Traité du feu et du* 08). Its true composition was determined by Liebig and Wöhler (Ann. harm. iii. 249). It occurs ready formed in gum-benzoin, dragon's blood, Peru and Tolu balsams, and in many other resins and balsams; also in casto- Wöhler, Ann. Ch. Pharm. lxvii. 360), in the spindle tree, *Euonymus europæus*, eizer, J. pr. Chem. 411, 437), and in the putrefied urine of man and of grami- us animals (Liebig, *ibid.* l. 168).

ation.—It is formed in a great number of organic reactions. 1. By the oxida- hydride of benzoyl, even by its exposure to moist air. 2. By the action of on chloride, bromide, or iodide of benzoyl. 3. By heating benzylic alcohol with s chromic acid. 4. By the action of nitric acid on hydride of cinnamyl, cinna- d, cinnamol, cumol, and cuminol. 5. By oxidising casein or gelatin with sul- acid and binoxide of manganese (Guckelberger, Ann. Ch. Pharm. lxiv. 80). n hippuric acid, by putrefaction, or by boiling with acids or alkalis. 7. By the of dilute alkalis on populin. 8. By the dry distillation of insolinic (Hofmann) inic acids (Wöhler, Ann. Ch. Pharm. li. 145).

aration. — Gum-benzoin is employed for the preparation of benzoic acid on the cale; the process may be conducted either in the dry or wet way. The best of preparing it in the dry way, or by sublimation, is that given by Mohr, h. Pharm. xxix. 177). The coarsely-powdered resin is placed at the bottom of l shallow iron-pot, 8 inches in diameter and 2 inches deep; the mouth is closed aphragm of coarse filter-paper, closely cemented to the sides of the vessel; and is is tied a covering of thick paper, in size and shape like a hat. The vessel heated gently and slowly on a sand-bath (1 lb. of gum requires 3 or 4 hours), oving the paper-cover when the whole is cool, it is found lined with a crystalline ate of benzoic acid. The diaphragm allows the vapours of benzoic acid to pass

through it, purifies them in great measure from empyreumatic products, and pre
the sublimed acid from falling back into the vessel. About 4 per cent. acid is
obtained: if the residue in the iron vessel be broken up and again heated, the
may be increased to 12½ per cent. The acid prepared by this method, which is o
whole the best for pharmaceutical purposes, is quite pure, with the exception of
of a volatile oil, which gives it a smell like that of vanilla, and on which its m
properties depend, at least to some extent.—The extraction of the acid from
benzoin may be effected more completely in the wet way. **Scheele's** process (
ii. 23) is to mix 2 pts. resin with rather less than 1 pt. quick lime, which i
slaked, to digest the mixture for some hours with 20 pts. cold water, and to bo
whole for half an hour. The solution containing benzoate of calcium is f
from the residue, which is then washed with hot water, evaporated to one-hal
mixed with excess of hydrochloric acid; the benzoic acid which crystallises out on c
is purified by recrystallisation from hot water, or by sublimation. If sodic carbon
employed instead of lime, a portion of the resin is apt to be dissolved, which colou
benzoic acid, and cannot be removed without difficulty. **Wöhler** (Ann. Ch. P
xlix. 245) gives the following method:—Powdered gum-benzoin is dissolved b
aid of heat in an equal volume of alcohol of 90—95 per cent., the hot solution
with fuming hydrochloric acid till the residue begins to be precipitated, and the
distilled as long as its consistency permits; it is then allowed to cool, and agai
tilled with water as long as any benzoic ether passes over. The joint distillate
taining benzoic ether, alcohol, and hydrochloric acid, are heated with caustic
until the ether is entirely decomposed, and the resulting solution of potassic be
decomposed by hydrochloric acid. The acid thus obtained precisely resemble
prepared by Mohr's method.

Benzoic acid may also be prepared from hippuric acid by boiling it for half a
with strong hydrochloric acid, and washing the product with cold water. B
acid is sometimes met with in commerce, which is prepared from the urine of
nivorous animals. The urine is allowed to putrefy, then mixed with milk of lim
filtered; and the filtrate is evaporated and precipitated by hydrochloric acid.
resulting benzoic acid be coloured, it is redissolved in thin milk of lime, the whole
with chloride of calcium, hydrochloric acid added, and the precipitate recrystallised
boiling water. The acid thus prepared is inferior to and cheaper than that ob
by sublimation. It always smells of urine, and never has the peculiar smell
sublimed acid.

Properties.—Benzoic acid crystallises in colourless, transparent, pearly need
laminæ, which, under the magnifying glass, appear to be six-sided prisms. It h
smell, and a faint but persistent sour and warm taste. It reddens litmus. It
at 121·4° C. to a colourless liquid of specific gravity 1·0838 (water at 0° being ta
unity), and boils without decomposition at 249·2° (at 740 mm. pressure) (**Kopp**
begins to sublime at a much lower temperature, and distils over abundantly
vapour of water. Its vapour-density is 4·27 (**Mitscherlich**); the vapours
coughing. It dissolves in 200 pts. cold, and in 24—30 pts. boiling water, much
readily in alcohol and ether. Fats and volatile oils dissolve it abundantly. It dis
in strong sulphuric acid without decomposition, and is reprecipitated by water.
not attacked by boiling dilute nitric or chromic acid; and is thus distinguished
cinnamic acid, which, under these circumstances, yields hydride of benzoyl.

Decompositions.. 1. *By heat.*—When vapour of benzoic acid is passed thro
red-hot tube filled with fragments of pumice-stone, it is decomposed into benzon
carbonic anhydride. The same decomposition takes place at a lower temperature
1 pt. acid is heated in a retort with 5 or 6 pts. coarsely powdered pumice.
much heat be applied, naphthalin and some empyreumatic products are also fo
and a residue of carbon left (**Barreswil** and **Boudault**). If benzoic acid be
with lime, only benzene passes over, the carbonic anhydride being retained by the
Heated in contact with air, benzoic acid burns with a bright smoky flame, and
no residue. 2. Dry *chlorine* acts upon benzoic acid in sunlight, forming a re
tough, gummy mass, whence potassic carbonate extracts chlorobenzoic acid (see b
and leaves a brown-red residue, which smells of benzoin, and contains ch
(**Herzog**). *Bromine* acts on benzoic acid in similar a manner. When ch
is passed into a hot aqueous solution of benzoic acid, or when benzoic acid is
with aqueous chloride of lime, or with potassic chlorate and hydrochloric acid,
ture of mono-, di-, and tri-chlorobenzoic acids is obtained; but these acids have no
separated and examined (**Stenhouse**, Ann. Ch. Pharm. lv. 10). When a solu
benzoic acid in excess of potash is saturated with chlorine, chloroniceic acid, C^8H
is produced (**St. Evre**). 3. When benzoic acid is heated with strong *nitri*
nitrobenzoic acid is formed: a mixture of sulphuric and fuming nitric acid conv
into dinitrobenzoic acid. 4. Fuming *sulphuric acid* converts it into sulphob

5. Heated to 200° C. with a mixture of anhydrous acid sulphate of sodium,
SO^4) and chloride of sodium, it yields chloride of benzoyl together with hydro-
acid.

$$C^7H^6O^2 + SO^3 + 2NaCl = C^7H^5OCl + HCl + Na^2SO^4.$$

ntral sulphate of sodium is associated with the sulphuric anhydride to prevent
ter from converting the benzoic acid into sulphobenzoic acid (Beketoff,
n. Pharm. cix. 256). 6. *Perchloride of phosphorus* does not act upon benzoic
l heat is applied, when hydrochloric acid is evolved, and chlorides of benzoyl
phosphoryl formed. 7. In the animal organism, benzoic acid is converted into
c acid, which is found in the urine. (Wöhler, &c.)

OATES.—Benzoic acid decomposes carbonates, but an alcoholic solution of
e benzoate is decomposed by carbonic anhydride, potassic carbonate being pre-
d. It is a monobasic acid, but forms some acid and basic salts. The normal
es are mostly crystallisable, and soluble in water and alcohol. Their aqueous
ns are decomposed by almost all acids, benzoic acid being precipitated. Alkaline
aline-earthy benzoates yield, by dry distillation, benzene, benzone, solid hydro-
isomeric with naphthalin, and a metallic carbonate. A mixture of benzoate
rmate of potassium yields, when heated, hydride of benzoyl (Piria). With
e of phosphoryl, alkaline benzoates yield chloride of benzoyl and a phosphate;
hloride of benzoyl, an alkaline chloride and benzoic anhydride. With
ride of phosphorus or chloride of sulphur, they yield either chloride of benzoyl
oic anhydride, according to the proportion of benzoate present.

zoate of Ammonium. *a. Normal.*—Obtained in crystals by cooling a solu-
benzoic acid in strong warm ammonia; or by evaporating a more dilute solution
dition of ammonia from time to time. It deliquesces in the air, and is soluble
r and alcohol, but less so in the latter than the potassic salt. When heated
tort, it loses water, and is converted into benzo-nitrile. Its solution loses
ia on evaporation, yielding:

id salt.—Obtained in large irregular crystals by the spontaneous evaporation of
tion of *a*. Less soluble than *a* in water and alcohol.

zoate of Barium, $C^{14}H^{10}Ba''O^4$ + 2Aq.—Slender permanent needles
msdorf), or large tables, which become opaque at 100° C. (Plantamour),
e their water at 110° (Limpricht).

zoate of Cadmium, $C^{14}H^{10}Cd''O^4$ + 2Aq.—By evaporating a solution of
ate of cadmium in aqueous benzoic acid, shining aggregated needles are obtained,
in hot water, sparingly in alcohol. (Schiff.)

zoate of Calcium, $C^{14}H^{10}Ca''O^4$ + 2Aq.—Crystallises in feathery needles or
ules, soluble in 29 pts. cold, and in less hot water.

zoate of Copper.—A hot solution of sulphate of copper gives with potassic
e an aggregate of bluish-green needles (Ettling), which are anhydrous
herlich). It dissolves in warm dilute acetic acid, and crystallises thence in
reen needles. It is insoluble in alcohol. By dry distillation it yields benzene,
acid, benzoate of phenyl, and an oil which boils at 260° C., and, when heated
lphuric acid, is decomposed into hydrate of phenyl and a solid hydrocarbon,
the residue contains salicylate of copper.

ric Benzoate.—The normal salt crystallises in yellow needles from a solution
c hydrate in aqueous benzoic acid; it is soluble with decomposition in water
ohol, a basic salt being left behind. A still more basic salt is obtained when
on of ferric chloride, containing enough ammonia to give it a dark-red colour,
ed with an alkaline benzoate: it is a flesh-coloured precipitate, insoluble in,
t decomposed by, cold water, and containing 17·5 per cent. iron. (Berzelius.)

rous Benzoate crystallises in needles, which effloresce and turn yellow when
l to the air, and are soluble in water and alcohol. Benzoate of ammonium does
cipitate ferrous salts.

zoate of Lead. $C^{14}H^{10}Pb''O^4$ + Aq.—A light crystalline powder, obtained by
tating normal lead-salts with potassic benzoate. It melts a little above 100° C.,
ves off its water (Berzelius). When digested with basic acetate of lead, it
lly becomes heavy and granular, being converted into a compound of basic
te and acetate of lead (Varrentrapp). A basic salt, $C^{14}H^{10}Pb''O^4.2Pb''O$, is
d by digesting the normal salt with ammonia, or precipitating benzoate of
ium with sub-acetate of lead.

zoate of Magnesium.—Feathery efflorescent crystals, readily soluble in

ganous Benzoate. $C^{14}H^{10}Mn''O^4$ + Aq.—Transparent, colourless, permanent

needles, soluble in 20 pts. cold, and in a much smaller quantity of boiling w
sparingly soluble in alcohol.

Mercuric Benzoate. $C^{14}H^{10}Hg''O^4$ + Aq.—A white precipitate, made
slender needles, obtained by adding an alkaline benzoate to a solution of corr
sublimate. It is insoluble in cold, tolerably soluble in hot, water; alcohol and
decompose it, leaving a basic salt, which may also be obtained by boiling benzoic
with water and excess of mercuric oxide. When treated with ammonia, mer
benzoate is converted into *ammonio-mercuric benzoate*, a white powder, insolub
water, almost insoluble in alcohol or ether; potash turns it yellow, and elimi
ammonia: it contains 69·92 per cent. mercuric oxide. (**Harff.**)

Mercurous Benzoate. $C^{14}H^{10}(Hg^2)''O^4$ + Aq.—A bulky crystalline precip
consisting of slender needles; insoluble in cold water; decomposed by boiling
or alcohol, with separation of metallic mercury. Becomes light-yellow when ex
to the light. Treated with ammonia, it is converted into a black powder, conta
80·9 per cent. mercurous oxide.

Benzoate of Potassium. a. Normal. $C^7H^5KO^2$ + Aq.—Crystallises with
culty from an aqueous solution, more easily from hot alcohol, in feathery needl
pearly laminæ. It is very soluble in water, has a sharp burning taste, and at 1
loses its water. Heated with arsenious hydride, it yields benzene. (**Darcet.**)

b. Acid salt. $C^7H^5KO^2 + C^7H^6O^2$.—Formed in the preparation of acetic anhy
from chloride of benzoyl and acetate of potassium; the residue is washed with
dried, and dissolved in boiling alcohol, when the acid benzoate crystallises in
laminæ. It is slightly soluble in cold water, or in boiling alcohol. (**Gregory.**)

Benzoate of Silver.—A white curdy precipitate, obtained by double decompos
it dissolves in a large quantity of boiling water, and crystallises thence in long s
laminæ. When heated, it melts and swells up, and leaves very white metallic
It dissolves in 1·96 pts. alcohol, at 100° C. (**Mitscherlich.**)

Benzoate of Sodium. Efflorescent pointed crystals, soluble in water, spa
in alcohol.

The *cobalt-*, *nickel-*, and *zinc-salts* are crystallisable and soluble in water and al
the *aluminium-salt*, crystalline, tolerably soluble in water: the *lithium-salt*, u
tallisable, very soluble: the *bismuth-*, *cerium-*, *tin-*, *yttrium-*, and *zirconium-sal*
white precipitates, sparingly soluble in water.

BENZOIC ETHERS. *Benzoate of Methyl. Benzoeformester.* $C^8H^8O^2 = C^7H^5(C$
(**Dumas** and **Peligot** [1835]; Ann. Ch. Phys. [2] lviii. 50; **Malaguti**, *ibi*
lxx. 387.)—Formed, according to Scharling, in the dry distillation of tolu-b
For its preparation, 2 pts. benzoic acid, 1 pt. wood-spirit, and 2 pts. strong sulp
acid, are distilled together, the residue redistilled two or three times with fresh
spirit, and the united distillates mixed with water. The impure benzoate of
which is thus precipitated, is washed, dried over chloride of calcium, and re
over oxide of lead, that portion which comes over above 198° C. being collected
It may also be prepared by distilling sulphate of methyl with potassic benzoat
is a colourless, oily liquid, with a pleasant balsamic smell, insoluble in water,
in alcohol and ether: boils at 198°·5 C. at 761 mm., or at 199°·2 at 746 mm. (K
Specific gravity 1·10 at 17°, or 1·0876 at 16·3 (**Kopp**): vapour-density, by e
ment, 4·717. Its vapour, passed through a red-hot tube filled with lime, yields,
other products, benzene. It absorbs chlorine without apparent alteration: whe
saturated liquid is heated, hydrochloric acid and chloride of methyl pass over
and then chloride of benzoyl in abundance; the coloured residue contains benzoic
benzoate, and (probably) chlorobenzoate of methyl.

Benzoate of Ethyl. Benzoevinester. $C^9H^{10}O^2 = C^7H^5(C^2H^5)O^2$. (**Scheele**,
ii. 141; **Dumas** and **Boullay**, Ann. Ch. Phys. [2] xxxviii. 20; **Wöhler** and **Li**
Ann. Ch. Pharm. iii. 274; **Deville**, Ann. Ch. Phys. [3] iii. 188.)—Benzoate of
is not formed by the mere contact of benzoic acid and alcohol, however prolonged
the reaction takes place gradually when the mixture is heated to 100° C. in a sealed
or when a small quantity of a strong acid is added to it. The statements of Devill
Cahours, that it is formed by the dry distillation of tolu-balsam and gum-benzoin.
to require confirmation. It is prepared by distilling 4 pts. alcohol with 2 pts. be
acid, and 1 pt. fuming hydrochloric acid, till two-thirds have passed over, and po
back the distillate into the retort two or three times: a little of the ether passes
but the greater part remains in the residue, whence it is separated by additi
water. Or a solution of 3 pts. benzoic acid in 2 pts. boiling alcohol of 80 per ce
heated for some time. Liebig and Wöhler prepare it by dissolving chloride of be
in absolute alcohol: heat and hydrochloric acid are evolved, and the addition of
separates the ether. The ether prepared by any of these methods, contains some

, from which it is purified by agitation with sodic carbonate, washing with
rectification over oxide of lead.
of ethyl is a colourless oil, with a pleasant aromatic smell, and a pungent
at 212·9° C., when the barometer stands at 745·5 mm. Specific gravity
0°·5 C. (**Kopp**). Vapour-density by experiment, 5·406. It is slightly
ater, soluble in all proportions in alcohol and ether. It burns with a bright
. Chlorine does not act upon it below 60° or 70° C., when hydrochloric
oride of ethyl pass over: on heating the mixture, a colourless distillate
at 190°, to which **Malaguti** (Ann. Ch. Phys. [2] lxx. 374), assigns the
$H^{14}Cl^6O^3$, regarding it as a compound of chloride of benzoyl with bichloro-
the black residue, when further heated, yields chloride of benzoyl. Nitric
ixture of nitric and sulphuric acids, converts it into nitrobenzoate of ethyl.
acked by perchloride of phosphorus (**Cahours**). When distilled over fused
zinc, it yields chloride of ethyl and benzoate of zinc, which latter is de-
y further heat, forming benzoic acid and benzene. Ammonia acts upon it
e ordinary temperature; but, if the mixture be heated above 100° C. in a
benzamide is readily formed. Aqueous potash converts it very slowly into
potassic benzoate: when heated with solid potash or potash-lime, hy-
olved, and benzoate and acetate of potassium formed (**Dumas and Stas**).
upon it between 60° and 70° C.: the liquid turns brown, without evo-
, yielding, among other products, the ether of a peculiar acid. (See HYPO-
ACID.)

e of Ethylene. Benzoate of Glycol. $C^{16}H^{14}O^4 = (C^7H^5O)^2.(C^2H^4)''.O^2$.
on and Wurtz, Ann. Ch. Phys. [3] lv. 400.)—Obtained by the action of
ethylene on benzoate of silver. It is soluble in ether, and crystallises
lution in colourless, shining, right-rhombic prisms. Melts at 67° C., and
out alteration at a temperature above the boiling point of mercury.

e of Amyl. $C^{12}H^{16}O^2 = C^7H^5(C^5H^{11})O^2$ (**Rieckher**, (1847), Jahr. pr.
15).—Obtained by distilling 1 pt. fusel-oil and 2 pts. sulphuric acid with
kaline benzoate. It is a yellowish oil of peculiar smell: boils at 260·7° C.
rometer stands at 745·6 mm. Specific gravity 0·9925 at 14°·4 (**Kopp**):
mposed by alcoholic potash.

e of Allyl. Benzoepropylenyl. $C^{10}H^{10}O^2 = C^7H^5(C^3H^5)O^2$ (**Zinin**, Ann. Ch.
i. 362; **Cahours and Hofmann**, *ibid.* cii. 297; **Berthelot and De**
Ch. Phys. [3] xlviii. 286).—Obtained by distilling equal quantities of
yl and benzoate of silver, washing the distillate with sodic carbonate, and
ver oxide of lead. Also by the action of chloride of benzoyl on allylic
yellow aromatic oil, heavier than water: boils at 230°—240° C.: insoluble
uble in alcohol or ether: decomposed by boiling with potash.

e of Benzyl. Benzoate of Tolyl. (**Canizzaro.**) $C^{14}H^{12}O^2 = C^7H^5(C^7H^7)O^2$.
oride of benzoyl and benzylic alcohol are distilled together in equal propor-
chloric acid is evolved, benzoic acid and chloride of benzyl pass over, and
oate of benzyl, in the form of a yellowish oil, which crystallises on cooling.
ed by pressure between filter-paper, rectification over benzoic anhydride,
h sodic carbonate, and another rectification. It forms colourless crystal-
, which melt below 20° C., and boil at about 345°. After fusion, it recrys-
great difficulty, often requiring the aid of a freezing mixture. It is isomeric
n.

e of Glycyl. See BENZOICIN.

e of Phenyl. Benzophenid. Benzoeoxyd. Benzocarbolic acid. $C^{13}H^{10}O^2 =$
O^2. (**Ettling** (1845), Ann. Ch. Pharm. liii. 87; **Stenhouse**, *ibid.* liii.
nt and Gerhardt, *ibid.* lxxv. 75; **List and Limpricht**, *ibid.* xc. 190.)
by the action of chloride of benzoyl on phenylic alcohol or phenylate of
by the dry distillation of benzoate of copper (**Ettling**): by heating ben-
anhydride (**Gerhardt**). List and Limpricht have shown the identity of
ces obtained by all these methods. It is best prepared by heating phenylic
chloride of benzoyl, as long as hydrochloric acid is evolved, washing the
product with potash, exhausting it with ether-alcohol, and evaporating the
crystallisation. To obtain it from benzoate of copper, the dry salt is dis-
the open fire as long as vapours are evolved; the distillate again distilled
of sodic carbonate, as long as benzene passes over with aqueous vapour; the
sidue in the retort separated from the alkaline liquid, washed with water,
ed in hot alcohol; and the crystals which separate on cooling, purified by
ystallisation from hot alcohol. (**List and Limpricht.**)
of phenyl forms hard, shining, colourless, rhombic prisms, often half an

inch long. It melts at 66° C., and cools to a crystalline mass: at a higher tem
it volatilises undecomposed. It has a faint smell of geraniums, or, when be
lemons: is insoluble in water, soluble in alcohol and ether, especially on hea
burns with a red, very smoky flame. Chlorine and bromine convert it into sub
products (see below). Sulphuric acid dissolves it readily; the addition o
separates benzoic acid, while sulphophenylic acid remains in solution. Boilin
chloric acid does not attack it. It is not decomposed by boiling with aqueous
but, if the mixture be heated to 150°—170° C. in a sealed tube, potassic benz
phenylate are formed: the same decomposition is effected by fusion with solid
or by contact with alcoholic potash, even in the cold. It may be boiled with
ammonia without decomposition; if the mixture be heated to 150° C. in a sea
phenylic alcohol and benzamide are formed, but no aniline. It is similarly
posed when distilled in a stream of dry ammonia. Perchloride of phosphorus
attack it. (List and Limpricht.)

Substitution-products of Benzoate of Phenyl.

1, 2, or 3 at. H in benzoate of phenyl may be replaced by Br, Cl, or NO^2
substitution-products are obtained either by the direct action of chlorine, br
nitrosulphuric acid, on benzoate of phenyl; or by the action of chloride of be
the substitution-products of hydrate of phenyl.

Benzoate of Bromophenyl, $C^{13}H^9BrO^2 = C^7H^5(C^6H^4Br)O^2$, and of *D*
phenyl, $C^{13}H^8Br^2O^2 = C^7H^5(C^6H^3Br^2)O^2$. *Bromo-* and *Dibromo-benzophenid*
and Limpricht, *loc. cit.*)—When dry benzoate of phenyl is treated with bromin
as any hydrobromic acid is evolved, the excess of bromine distilled off, and th
repeatedly crystallised from hot alcohol, large colourless needles are obtaine
melt below 100° C., sublime undecomposed, and are insoluble in water, but so
hot alcohol and ether. From the great variation in the analyses, this com
certainly a mixture of at least two substitution-compounds: and it is prob
tribromobenzophenide is present also. The substance is dissolved and decom
cold alcoholic potash, into benzoic, bromophenylic, and dibromophenylic acids

Benzoate of Chlorophenyl. Chlorobenzophenid. $C^{13}H^9ClO^2 = C^7H^5(C^6$
(Stenhouse, *loc. cit.*)—When dry chlorine is led for some days over fused
of phenyl, a dark-yellow mixture is produced, consisting of an oily and a so
having a very pungent smell: this is pressed between filter-paper, and the s
due repeatedly crystallised from ether. Large flat crystals are thus obtaine
melt at 84° C., and sublime in four-sided prisms: they have a faint smell, lik
sesquichloride of carbon. From analyses, this substance appears to be a m
chloro- with dichloro-benzophenide. The oily substance contains more chlor
probably consists in part of trichlorobenzophenide. Both compounds, when hea
alcoholic potash, yield chloride and benzoate of potassium, and on addition o
chloric acid, a dark, resinous body, smelling of creosote, which is probabl
chlorophenylic acid.

Benzoate of Dinitrophenyl. Dinitrobenzophenide. $C^{13}H^8N^2O^6 = C^7$
$(NO^2)^2)O^2$. (Laurent and Gerhardt, *loc. cit.*)—Dinitrophenylic acid is hea
chloride of benzoyl, as long as hydrochloric acid is evolved; and the product is
with dilute ammonia, washed with cold alcohol, and crystallised from boiling
Yellow rhombic laminæ, insoluble in water, slightly soluble in hot alcoh
readily in warm ether, partly soluble in potash.

Benzoate of Trinitrophenyl. Trinitrobenzophenide. $C^{13}H^7N^3O^8 = C^7$
$(NO^2)^3)O^2$.—Prepared like the preceding compound, trinitrophenylic (picric) a
substituted for dinitrophenylic acid. Shining yellow rhombic laminæ, less solu
menstrua than the dinitro-compound. When heated, it melts and solidi
crystalline mass: heated more strongly, it explodes. Dissolves in boiling pota
ing a dark-red solution, whence acids precipitate crystalline flakes.

Substitution-products of Benzoic Acid.

Bromobenzoic Acid. $C^7H^5BrO^2$. (Péligot [1836], Ann. Ch. Pharm. **xxv**
Herzog, N. Br. Arch. xxiii. 16; Müller, Compt. rend. **xxx.** 325.)—Benzoi
treated with bromine in the sunshine, the excess of bromine distilled off, th
dissolved in sodic carbonate (when an oil containing bromine remains undi
and the solution precipitated by nitric acid (Herzog). Péligot makes
vapour act upon benzoate of silver, by placing the salt, together with a tube
ing bromine, in a closed vessel, and leaving it for twenty-four hours: from th
the bromobenzoic acid is dissolved out by ether. The solution, on evaporatio
a brown oil, which crystallises on cooling: this is dissolved in potash, trea
animal charcoal, and reprecipitated by nitric acid. It forms a colourless cr

nelts at 100° C., and sublimes at 250°, leaving a residue of carbon. It
smoky green-edged flame: is sparingly soluble in water, readily in alcohol

oates are generally soluble and crystallisable: the *lead-*, *copper-*, and
ts are less soluble. The *silver-salt*, $C^7H^4AgBrO^2$, is soluble in warm

zoic Acid. *Chloromichmylic acid.* $C^7H^5ClO^2$. (Herzog, 1840, N. Br.
; Scharling, Ann. Ch. Pharm. xli. 49; xlii. 268; Stenhouse, *ibid.* lv. 1;
xv. 55; Limpricht and v. Uslar, *ibid.* cii. 259; Chiozza, Ann. Ch.
vi. 102).—When dry benzoic acid is acted on by chlorine, a moist viscid
is formed, which appears to contain a mixture of mono-, bi-, and tri-
acids; these acids (which Stenhouse also obtained by treating benzoic
oride of lime and hydrochloric acid), cannot be separated from each other.
d Uslar obtained pure chlorobenzoic acid from chloride of chlorobenzoyl.
them, the acid obtained by Chiozza, by the action of perchloride of
n salicylic acid, is not identical, but isomeric, with chlorobenzoic acid:
ribe it separately as *parachlorobenzoic acid.* There is no doubt that the
ylic acid obtained by Scharling by distilling urine with nitric acid, is
chlorobenzoic acid.
and Uslar boil chloride of chlorobenzoyl (obtained by the action of per-
hosphorus on chlorosulphobenzoic acid) with potash, and saturate the
hydrochloric acid: the precipitated chlorobenzoic acid is purified by re-
with a base and reprecipitation by an acid. It forms colourless, concen-
ed prisms, which melt at about 140° C., but sublime at a lower tempe-
all needles. It dissolves sparingly in cold water, readily in hot water,
her. Fuming nitric acid converts it into nitrochlorobenzoic acid. The
es are generally soluble. The solution of the *ammonium-salt* gives off
ndantly when evaporated, so that the residue is nearly pure chlorobenzoic
id which Field obtained by boiling benzoic acid with potassic chlorate and
acid, melts with difficulty, and blackens when heated. The *barium-* and
crystallise with 3 aq., which they lose at 100° C. The *lead-salt* is a white
hich melts and turns yellow at 110°. The *potassium-* and *sodium-salts*
isable. The *silver-salt*, $C^7H^4AgClO^2$, is a white precipitate, consisting of
needles. *Chlorobenzoic ether* (chlorobenzoate of ethyl), $C^9H^9ClO^2$ =
lO^2, is obtained by treating the acid with alcohol and sulphuric acid, or
lorobenzoyl with alcohol, and precipitating the product with water. It
elling like benzoate of ethyl, and boiling at 245° C. It dissolves in nitro-
, and water precipitates from the solution an oil which gradually solidifies
probably of *nitrochlorobenzoic ether.*
benzoic Acid, $C^7H^5ClO^2$ (Chiozza, *loc. cit.*)—Salicylic acid is distilled
ide of phosphorus, and the distillate rectified, when a heavy, strongly re-
asses over between 200° and 250° C., which is converted gradually by cold,
by hot water, into hydrochloric and parachlorobenzoic acids: the oil is
chloride corresponding to the acid. Parachlorobenzoic acid forms
ning crystals, like those of salicylic acid, from which it is distinguished
violet colour with ferric salts. It melts at 130° C., and sublimes unde-
issolves readily in hot water, and the saturated solution solidifies on
mass of needles. Some of its salts differ from the corresponding chloro-
the amount of water of crystallisation which they contain: thus the
anhydrous, and the *calcium-salt* contains 1 aq. The *silver-salt* may be
ather large crystals.

oic Acid, $C^7H^5NO^4 = C^7H^4(NO^2)O^2$. (Plantamour [1839], Ann. Ch.
349; Mulder, *ibid.* xxxiv. 297; Abel, *ibid.* lxiii. 313; Bertagnini,
59; Blumenau, *ibid.* lxxxvii. 127; Gerland, *ibid.* xci. 185). Mulder's
ating benzoic acid with fuming nitric acid, is a long process. Gerland
agitating 1 pt. benzoic acid and 2 pts. nitre with strong sulphuric acid,
he whole till it softens: the resulting nitrobenzoic acid is purified by
from boiling water. The acid is also formed by the decomposition of
ic compounds: by the oxidation of hydride of nitrobenzoyl by chromic
gnini): by boiling cinnamic acid and other cinnamyl-compounds (Plan-
ılder), cumene (Abel), or dragon's blood (Blumenau), with nitric
ting nitrohippuric acid with hydrochloric acid (Bertagnini). Nitro-
orms colourless laminæ, generally grouped together. It melts at 127° C.,
at 110°, and if pure, leaves no residue: the vapours excite coughing.
it blackens and decomposes. It dissolves in 400 pts. water, at 10°,
at 100°, forming strongly acid solutions; it melts in water below 100°,

to a heavy oil: is readily soluble in alcohol and ether. Strong nitric or hydr
acid dissolves it without decomposition: but it is decomposed by prolonged
with nitric acid. It dissolves in cold sulphuric acid: on heating the solutio
nitrobenzoic acid sublimes, and near the boiling point of sulphuric acid the
becomes red, a peculiar compound being formed (Mulder). It is not ait
sublimation in dry chlorine. Perchloride of phosphorus attacks it when
yielding chlorides of nitrobenzoyl and of phosphoryl. With sulphide of amm
forms benzamic acid (*q. v.*) In the animal system it is converted into nitro
acid, which appears in the urine.

Nitrobenzoates are generally crystallisable and soluble in water and alcoh
explode when heated, and give off nitrobenzol. Nitrobenzoic acid is a strong
decomposes the salts of many other acids. The normal *ammonium-salt* loses
when heated, and yields an acid salt, which also crystallises when the solutio
normal salt is evaporated: the normal salt on prolonged fusion, yields nitrobe
(Field). The *barium-salt*, $C^{14}H^8Ba''N^2O^8$ + 4 aq., forms fine crystals which l
water at 100° C. The *calcium-salt* contains 2 aq., which it loses at 130°–
The *copper-salt* is a blue powder, which separates on cooling from a hot mixtu
acid with cupric acetate: at 130° C. it loses water and some acid. The *ferr*
anhydrous: it is obtained as a bulky flesh-coloured powder, when a boiling
of the acid is precipitated by ferric chloride. The normal *lead-salt* is obtained
tals when a boiling solution of the acid is added to basic acetate of lead, until
nent precipitate is formed: it is decomposed by washing with water, and yie
salts.

The *manganese-salt* contains 4 aq., two of which it loses below 100°, the
133° C. The *potassium-* and *sodium-salts* crystallise with difficulty: when
they are decomposed, emitting sparks. The *silver-salt*, $C^7H^4AgNO^4$, is obt
pearly laminæ, by crystallising from hot water the precipitate which nitrobe
ammonium gives with nitrate of silver: at 120° C. it turns grey, and loses
250° it explodes in closed vessels, forming nitrobenzenel. The *zinc-salt* contain
which it loses at 140°: it crystallises from the filtrate which runs off from the g
precipitate formed by nitrobenzoate of ammonium with sulphate of zinc: t
cipitate is a basic salt.

Nitrobenzoic Ethers. Nitrobenzoate of Methyl, $C^8H^7NO^4 = C^7H^4(CH^3)$
(Chancel, Compt. Chim. 1849, 179; Bertagnini, Ann. Ch. Pharm. lxx
— Prepared in a similar manner to nitrobenzoate of ethyl, which it r
in all its reactions. It forms small, white, nearly opaque right rhombic
which melt at 70° and boil at 129° C.: are insoluble in water, slightly so
alcohol and ether, somewhat more in wood-spirit: have a faint aromatic smel
cooling taste.

Nitrobenzoate of Ethyl. $C^9H^9NO^4 = C^7H^4(C^2H^5)(NO^2)O^2$. (E. Kopp, Com
xxxiv. 615; Chancel, *loc. cit.*; Bertagnini, *loc. cit.*; List and Limprich
Ch. Pharm. xc. 206.)—A boiling alcoholic solution of nitrobenzoic acid is s
with hydrochloric acid: after some time water is added, and the precipitated
agitated with hot sodic carbonate, washed with cold water, dried between filte
and crystallised from ether-alcohol. Bertagnini prepares it by crystallising a so
chloride of nitrobenzoyl in alcohol; and List and Limpricht, by dropping be
ethyl into a mixture of 1 pt. nitric and 2 pts. sulphuric acid. It forms right
prisms, which melt at 42°, and boil at 298° C.: smells like strawberries, an
fresh taste; is insoluble in water, readily soluble in alcohol and ether. Boilin
decomposes it into alcohol and nitrobenzoic acid: with ammonia it forms n
zamide and alcohol: with sulphide of ammonium, benzamate of ethyl.

Nitrobenzoate of Dibromophenyl. (*Nitrobibromobenzophenide.*) $C^{13}H^7B$
$C^7H^4(C^6H^3Br^2)(NO^2)O^2$ (List and Limpricht, *loc. cit.*)—Separates as a re
benzoate of dibromophenyl is added to nitrosulphuric acid; the addition
scarcely precipitates anything more. It crystallises from hot alcohol in nodul
posed of small needles: from a concentrated solution, it separates as an oil.
between 90° and 100° C.: is insoluble in water, sparingly soluble in hot
Alcoholic potash decomposes it into nitrobenzoic and dibromophenylic acids.

Nitrobenzoate of Dinitrophenyl. $C^{13}H^7N^3O^8 = C^7H^4[C^6H^3(NO^2)^2](NO^2)O^2$ (L
Limpricht, *loc. cit.*)—Powdered benzoate of phenyl is added to cold nitros
acid, whereupon it dissolves, and yellow crystals separate out, which are increase
addition of water; these are washed, first with cold water, then with alcohol.
a white crystalline powder, which turns yellow when heated, and melts at 150
cooling, it solidifies to a yellow glass, which gradually becomes opaque. It is i
in cold water or alcohol, sparingly soluble in hot alcohol or in ether. He
platinum-foil, it burns with yellow smoky flame: heated in a tube, it explode
It is decomposed by alcoholic potash. Sulphide of ammonium dissolves it wi

by evaporation on a water-bath, a dark-violet resinous mass is obtained
le in acids.

benzoic Acid. $C^7H^4N^2O^6 = C^7H^4(NO^2)^2O^2$ (Cahours, Ann. Ch. Phys.
).—When fused benzoic acid is gradually added to a warm mixture of nitric
ric acids, it dissolves with slight evolution of gas: the whole is then
l hour, Cahours;—for 6 hours, Voit), and as soon as it begins to be turbid,
and water added, which precipitates yellow flakes, which are washed with
l, and crystallised from boiling alcohol. Dinitrobenzoic acid is thus ob-
ort shining prisms, which melt at a gentle heat, and sublime in delicate
is slightly soluble in cold, more in boiling, water; readily in alcohol or
ially on heating. It dissolves in hot nitric acid, and crystallises on cooling.
uric acid dissolves it unaltered, but decomposes it when heated strongly.
ammonium and other reducing agents convert it into diamidobenzoic acid.
e *dinitrobenzoates* are soluble and crystallisable: the *lead-* and *silver-salts*
soluble. *Dinitrobenzoic ether* (dinitrobenzoate of ethyl), $C^9H^8N^2O^6 =$
$(NO^2)^2O^2$, is obtained by saturating absolute alcohol with the acid, or heat-
d with alcohol and sulphuric acid: it forms oily drops, which solidify on
are washed with dilute ammonia, and crystallised from hot alcohol. Long
dles, with a slight yellow tinge: decomposed by strong potash, especially
into alcohol and potassic dinitrobenzoate. Digestion with alcoholic am-
rts it into dinitrobenzamide: sulphuretted hydrogen converts it into di-
ic acid. (Voit, Ann. Ch. Pharm. xcix. 100.)

lorobenzoic Acid. $C^7H^4NClO^4 = C^7H^4(NO^2)ClO^2$ (Limpricht and
nn. Ch. Pharm. cii. 261).—When chlorobenzoic acid is dissolved in fuming
there is no immediate precipitate, but the solution continues for several
osit colourless tables of nitrochlorobenzoic acid. These melt at 118° C.; are
alcohol and ether; melt in warm water, dissolve on boiling, and do not
t on cooling. The *barium-* and *silver-salts* only are known: the latter,
$O^4 + \frac{1}{2}$ Aq (?), forms small shining laminæ, tolerably soluble in water. For
enzoic ether, see above, *chlorobenzoic ether*. F. T. C.

IC ALCOHOL. Syn. with BENZYLIC ALCOHOL (*q. v.*)

IC ANHYDRIDE. *Benzoate of Benzoyl.* $C^{14}H^{10}O^3 = (C^7H^5O)^2.O$
t (1852), Ann. Ch. Phys. [3] xxxvii. 299; Wunder, J. pr. Chem. lxi.
tz, Pogg. Ann. xcii. 458).—Formed by the action of chloride of benzoyl on
lates or benzoates: also of oxychloride or perchloride of phosphorus, or
sulphur on alkaline benzoates, the first stage of the reaction being the
f chloride of benzoyl: also by the dry distillation of acetobenzoic and similar
:

$$C^7H^5KO^2 + C^7H^5OCl = C^{14}H^{10}O^3 + KCl.$$
$$C^2O^4K^2 + 2C^7H^5OCl = C^{14}H^{10}O^3 + 2KCl + CO + CO^2.$$
$$2C^7H^5KO^2 + PCl^5 = C^{14}H^{10}O^3 + 2KCl + POCl^3$$
$$8C^7H^5KO^2 + 3SCl^2 = 4C^{14}H^{10}O^3 + 6KCl + SO^4K^2 + S^2.$$

rts of dry benzoate of sodium and chloride of benzoyl are heated to 130° C. on
, whereby a clear liquid is produced, from which chloride of sodium separates
oled mass is washed with cold water containing sodic carbonate, and crys-
n ether or warm alcohol. The previous preparation of chloride of benzoyl
by employing perchloride or oxychloride of phosphorus (5 pts. oxychloride
zoate). Oxalate of potassium is heated with an equal weight of chloride
with constant agitation, till the smell of chloride of benzoyl has disappeared;
led mass is suspended in cold water, washed with water containing ammonia,
ised from alcohol (Gerhardt). In preparing large quantities, it is better to
product by distillation than by crystallisation from alcohol.

nhydride forms oblique rhombic prisms, sometimes smelling of bitter-almond
ic ether: it melts at 42° C., and distils undecomposed at about 310°. It
in cold water, soluble in alcohol and ether: the solution when fresh has no
n. It melts in boiling water, and remains fluid for a long time, even when
nd is slowly converted into benzoic acid, which dissolves. Caustic alkalis
much more rapidly into benzoic acid. Aqueous ammonia does not attack it
but dissolves it on heating, forming benzamide and benzoate of ammo-
same reaction takes place when it is heated in dry ammonia:

$$C^{14}H^{10}O^3 + 2NH^3 = C^7H^7NO + C^7H^5(NH^4)O^2.$$

s similarly, forming phenylbenzamide. (Gerhardt.)

n of benzoyl in benzoic anhydride is capable of being replaced by other acid
rming a series of anhydrides containing benzoyl. They are obtained by the

action of chloride of benzoyl on the alkaline salts of other monobasic acids,
versely, by treating alkaline benzoates with the chlorides of monobasic acid
They are generally decomposed by heat into two simple anhydrides: by wa
more rapidly by alkalis, into two acids.

Benzoacetic Anhydride. See Acetic Anhydride.

Benzoangelic Anhydride. $C^{12}H^{12}O^3 = C^5H^7O.C^7H^5O.O$ (Chiozza, Ann. C
[3] xxxix. 210).—Produced by gently heating chloride of benzoyl with an
potassium. It is a limpid oil, heavier than water, somewhat less fluid than
anhydride, and quite neutral to test-paper. It smells like angelic anhydride,
much more acrid vapours when heated. In a mixture of ice and salt, it
slightly, without crystallising.

Benzocinnamic Anhydride. *Benzoate of Cinnamyl.* $C^{16}H^{12}O^3 = C^7H^5O.$
(Gerhardt, *loc. cit.*)—Obtained by heating 7 pts. chloride of benzoyl with 1
cinnamate of sodium, and purifying the product as in the case of benzoic anhydr
a thick oil, colourless and odourless, which gradually becomes acid when exposed
air. Specific gravity 1·184 at 23° C. Is decomposed by distillation, yielding
oil, smelling of cinnamol, which gradually deposits crystals of benzoic anhyd
an acid substance soluble in sodic carbonate.

Benzocuminic Anhydride. *Benzoate of Cumyl.* $C^{17}H^{16}O^3 = C^7H^5O.C$
(Gerhardt, *loc. cit.*)—Obtained like the preceding, cuminate being substit
cinnamate of potassium. Resembles the preceding in appearance and beha
moist air. Specific gravity 1·115 at 23° C. Is decomposed by distillation: whe
in a closed vessel, it appears to volatilise without decomposition. Aqueous
converts it into cuminamide, and benzamide, or benzoate of ammonium.

Benzomyristic Anhydride. *Benzoate of Myristyl.* $C^{21}H^{32}O^3 = C^7H^5O.C$
(Chiozza and Malerba, 1855).—Obtained by heating chloride of benzoyl
ristate of potassium. Crystallises from boiling ether, in which it is slightly s
shining laminæ: melts at 38°, and solidifies at 36° C.

Benzoœnanthylic Anhydride. *Benzoate of Œnanthyl.* $C^{14}H^{18}O^3 = C^7H^5O.C$
(Chiozza and Malerba, Ann. Ch. Pharm. xci. 102).—Obtained by the
chloride of benzoyl on œnanthylate of potassium. Colourless oil, of specific grav
at 11° C.; smells like œnanthylic anhydride: exposed to the air, it yields cr
benzoic acid.

Benzopelargonic Anhydride. *Benzoate of Pelargonyl.* $C^{16}H^{22}O^3 = C^7H^5O.C$
(Chiozza, Ann. Ch. Phys. [3] xxxix. 310).—Prepared like the foregoing co
A heavy oil, resembling pelargonic anhydride. A little below 0° C. it solidifi
consistency of butter: is decomposed by heat into benzoic and pelargonic anh

Benzostearic Anhydride. *Benzoate of Stearyl.* $C^{25}H^{40}O^3 = C^7H^5O.C$
(Chiozza and Malerba, *loc. cit.*)—Prepared by heating chloride of benzoyl and
stearate in an oil-bath. Shining scales, which melt at 70° C.

Benzovaleric Anhydride. *Benzoate of Valeryl.* $C^{12}H^{14}O^3 = C^7H^5O.$
(Chiozza, Ann. Ch. Pharm. lxxxiv. 106).—Chloride of benzoyl acts violently
rate of potassium: the product is a heavy, neutral, strongly refracting oil,
like valeric anhydride. At about 260° C. it is decomposed into benzoic an
anhydrides.

Substitution-products of Benzoic Anhydride.

Benzonitrobenzoic Anhydride. *Benzoate of Nitrobenzoyl.* $C^{14}H$
$C^7H^5O.C^7H^4(NO^2)O.O$.—3 pts. chloride of benzoyl are heated with 7 pts. d
benzoate of sodium, and the product is purified as in the case of benzoic an
Crystalline: more stable than the following compound. (Gerhardt, *loc. cit.*

Nitrobenzoic Anhydride. *Nitrobenzoate of Nitrobenzoyl.* $C^{14}H$
$[C^7H^4(NO^2)O]^2.O$.—8 pts. nitrobenzoate of sodium are heated to 150° C. w
oxychloride of phosphorus, till the smell of chloride of nitrobenzoyl has disa
On treating the product with cold water, a white mass is obtained, almost ins
alcohol and ether, less fusible than nitrobenzoic acid, into which it is quick
verted by washing with water. (Gerhardt, *loc. cit.*) F.

BENZOIC ETHERS. See p. 552.

BENZOICIN. (Berthelot, Ann. Ch. Phys. [3] xli. 290.)—The name
Berthelot to the artificial fats obtained by the action of benzoic acid on
Glycerin being a triatomic alcohol, $C^3H^5.H^3.O^3$, contains 3 at. H replaceable
radicles; and Berthelot has succeeded in obtaining the compounds in which 1
respectively are replaced by benzoyl.

zoicin. *Benzoate of Glycyl.* $C^{10}H^{12}O^4 = C^3H^5.C^7H^5O.H^2.O^3$. — Ob-
nting benzoic acid with glycerin in a sealed tube, for forty-four hours, to
C. if the acid be in excess, to 200° C. if the glycerin be in excess; at a
rature a shorter time suffices. The product is purified by washing with
onate. It is a colourless, neutral, very viscid oil, with a bitter aromatic
light balsamic smell; specific gravity 1·228 at 16°·5 C. At 40° it is a
early solid mass, that can be drawn out into threads; it boils at 320°, but
t the same time, yielding acrolein and benzoic acid. It is insoluble in
ly soluble in bisulphide of carbon, readily in alcohol, ether and benzene.
ry slightly in the air. Heated with potash it forms potassic benzoate;
a, benzamide. Alcohol and hydrochloric acid convert it in the cold into
benzoate of ethyl; the same decomposition is effected when its alcoholic
ated to 100° C. for forty-eight hours.

icin. *Tribenzoate of Glycyl.* $C^{24}H^{20}O^6 = C^3H^5.(C^7H^5O)^3.O^3$. — Ob-
nting monobenzoicin for four hours to 250° C., with 10 or 15 pts. benzoic
duct is washed with sodic carbonate, and repeatedly crystallised from
ge white needles, unctuous to the touch, and fusing pretty readily.
hydrochloric acid decompose it like monobenzoicin. F. T. C.

N. *Bitter-almond-oil-camphor.* $C^{14}H^{12}O^2$. (Liebig and Wöhler,
arm. iii. 276; Robiquet and Boutron-Charlard, Ann. Ch. Phys.
Laurent, *ibid.* lix. 402; lxvi. 193; Zinin, Ann. Ch. Pharm. xxxiv. 186.)
ibed by Stange, 1823 (Repert. Pharm. xiv. 329); first correctly examined
d Wöhler in 1832. It is frequently contained in crude bitter-almond oil,
ed as a by-product when the oil is purified by lime and ferrous chloride;
treated with dilute hydrochloric acid, and dissolved in alcohol. Pure
oil (hydride of benzoyl) is converted into benzoin by cyanide of potas-
epare benzoin from crude bitter-almond oil, the oil is mixed with its own
saturated alcoholic solution of potash; after a few minutes, the whole
a mass of crystals, which are purified by recrystallisation from alcohol.
nt of benzoin in different specimens of the crude oil varies considerably,
their age and to the amount of prussic acid which they contain, it is always
test a small portion first with alcoholic potash; if it does not speedily
crude oil had better be first freed from prussic acid, and then treated by
ethod. Pure oil of bitter-almonds is readily converted into benzoin by the
dilute alcoholic solution of cyanide of potassium, or of alcoholic potash to
drops of hydrocyanic acid have been added: this reaction is difficult to

isomeric with benzoate of benzyl, and polymeric with hydride of ben-
ns shining, transparent, colourless prisms, without smell or taste; melts at
crystallises on cooling; if further heated, it distils undecomposed. It is
old, slightly soluble in hot water, whence it crystallises on cooling; more
t than in cold alcohol. It burns readily in the air, with a bright smoky
apour passed through a red-hot tube is reconverted into hydride of ben-
heated in *chlorine*, it yields benzil and hydrochloric acid. *Bromine* at-
ving hydrobromic acid, and forming (probably) benzil. Strong *nitric*
it into benzil. *Sulphuric acid* dissolves it, forming a violet solution,
ns when heated. Boiling *potash* does not attack it; fused with solid
olves hydrogen and yields benzoic acid: $C^{14}H^{12}O^2 + 2KHO = 2C^7H^5KO^2$
with alcoholic potash, it is coloured violet, and yields benzilic acid, with
hydrogen: $C^{14}H^{12}O^2 + KHO = C^{14}H^{11}KO^3 + H^2$. With *ammonia*, it
g other products, benzoinam and benzoinamide. *Perchloride of phos-*
s it violently, yielding chloride of phosphoryl, and other products diffi-
pure. (Cahours.)
mbines with chlorides of acid radicles, yielding compounds representing
hich 1 H is replaced by an acid radicle. Zinin (Ann. Ch. Pharm. civ.
ined the following: —

nzoin. $C^{16}H^{14}O^3 = C^{14}H^{11}(C^2H^3O)O^2$. — 4 pts. of benzoin dissolve in 3 pts.
etyl at 40°—50° C., with evolution of hydrochloric acid; when the solution
he whole is heated to 100° as long as vapours are evolved: on cooling, the
y solidifies into crystals, which are recrystallised from alcohol or ether.
from the ethereal solution in large rhombic prisms and six-sided tables;
oholic solution in thin shining crystals. It is insoluble in water, melts
and does not always crystallise on cooling. Sulphuric or hydrochloric
ous potash does not act upon it; with alcoholic potash it yields acetate
of potassium. Strong nitric acid converts it into a mixture of two nitro-
he form of a viscid colourless mass, insoluble in water, soluble in alcohol
he solution deposits crystals.

Benzoyl-benzoin. $C^{21}H^{16}O^3 = C^{14}H^{11}(C^7H^5O)O^2$.—Chloride of benzoyl does
upon benzoin in the cold, but at about 70° C. the benzoin dissolves and hydrochlor
is evolved; the whole is then heated to nearly the boiling point of chloride of
(196° C.), when a yellowish oily liquid is obtained, which solidifies into cryst
cooling. This product is purified by being poured while liquid into cold 75 pe
alcohol, when benzoyl-benzoin separates as a crystalline powder, which is washe
filter with cold alcohol. It is insoluble in water, sparingly soluble in cold alcohol,
in 6 pts. boiling 80 per cent. alcohol, whence it crystallises in thin colourless n
readily soluble in ether, and crystallises by spontaneous evaporation in large
rhombic prisms; soluble in chloride of benzoyl, and may be heated with it to 1
without alteration. Melts at 125° C., and crystallises very slowly on cooling. Ch
does not attack it, neither does hydrochloric or dilute sulphuric acid; strong sul
acid decomposes it. Aqueous potash does not attack it; alcoholic potash disso
with a violet colour, and, on boiling, converts it into benzoate and benzil
potassium.

Nitrobenzoyl-benzoin. $C^{21}H^{15}NO^5 = C^{14}H^{11}(C^7H^4(NO^2)O)O^2$.—Strong nitr
(specific gravity 1·51) dissolves benzoyl-benzoin, which, if too little acid be emp
crystallises out again unaltered; but if at least 1½ pt. acid be taken, and the yel
solution poured into cold water, a resinous substance separates, which is a mixt
two nitro-products. Ether dissolves one of these, and abandons it on evaporatio
thick oil; the other, which is nitrobenzoyl-benzoin, remains undissolved as a c
line powder, which is recrystallised from boiling alcohol. White shining scales
posed of rhombic tables, aggregated into scalariform groups, insoluble in water.
at 137° C., and solidifies at 110° to an amorphous mass, which very slowly be
crystalline. Strong nitric acid dissolves it unaltered and in large quantities, esp
if gently heated; on boiling the solution a new body is formed, soluble in
which separates as a powder on cooling. F. T

BENZOINAM. $C^{28}H^{24}N^2O$. (Laurent, Compt. Chim. [1845] 37).—Form
the action of alcoholic ammonia on benzoin:

$$2C^{14}H^{12}O^2 + 2NH^3 = C^{28}H^{24}N^2O + 3H^2O.$$

Obtained, together with benzoinamide and other products, when a mixture of al
ammonia and benzoin is left for some months in a closed vessel. Forms whi
croscopic inodorous needles, insoluble in water; slightly soluble in hot ether o
oil, whence it crystallises on cooling in very bulky needles, readily soluble
alcohol containing hydrochloric acid, whence it is partially precipitated by
entirely by ammonia. Melts when heated, and partly solidifies on cooling.
does not attack it; strong sulphuric acid dissolves it with red colour, and wat
cipitates orange flakes. F. T

BENZOINAMIDE. $C^{42}H^{36}N^4$. (Laurent [1837], Ann. Ch. Phys. [2
189.)—Formed by the action of aqueous ammonia on benzoin:

$$3C^{14}H^{12}O^2 + 4NH^3 = C^{42}H^{36}N^4 + 6H^2O.$$

Obtained as a white powder when benzoin and aqueous ammonia are left fo
weeks in a closed vessel; it is boiled in alcohol to remove excess of benzoi
crystallised from boiling ether. A white, tasteless, odourless powder, consisting
microscopic needles; insoluble in water, very sparingly soluble in alcohol or
melts when heated, and solidifies to a fibrous mass; distils without decompositio

BENZOIN-GUM. The commercial name of a resin which flows from the
Styrax benzoin, a tree growing in Sumatra, Borneo, Java, and Siam. It come
the market in different forms. The Siamese gum occurs in irregular flat frag
about an inch long, which are reddish-yellow on the outside, white and shining
inside. The common or Calcutta-gum forms larger irregular lumps, brittle, of
reddish-grey or brown colour, with many light coloured spots, and often contain
ments of wood and bark. The Siamese almond-gum appears to be a mixture o
these kinds. The commercial gum has a pleasant smell, especially when heate
a sweetish, sharp, balsamic taste. It melts when heated, evolves vapours of
acid, and burns with a smoky flame. Specific gravity 1·063—1·092. Alcoh
solves it completely, excepting impurities; ether partially; boiling water dissolv
benzoic acid.

According to Unverdorben (Pogg. Ann. viii. 397), Stolze (Berl. Jahrb.
xxvi. 75), Van der Vliet (Ann. Ch. Pharm. xxxiv. 177), and E. Kopp (C
rend. xix. 1269), gum-benzoin is a mixture of three resins, which may be disting
as α, β, and γ, together with benzoic acid, and a small quantity of a volatile oil.
whole of the benzoic acid cannot be driven off by heat. According to Kolbe and
mann (Ann. Ch. Pharm. cxv. 113), some varieties of gum-benzoin, especially the

of Sumatra, contain not benzoic acid, but an acid isomeric with toluylic acid, O^2, which melts to a clear liquid under hot water, crystallises in forms quite ent from that of benzoic acid, and yields hydride of benzoyl when treated with ing agents.

verdorben separates the resins in the following manner:—The powdered gum is ted with boiling sodic carbonate, which dissolves out all the benzoic acid and sin γ; the alkaline solution is precipitated by hydrochloric acid, and the preci- treated with boiling water, which dissolves the acid only, leaving the resin γ ble. The portion insoluble in sodic carbonate is washed, dried, and digested with which dissolves the resin α, and leaves the resin β undissolved. According to the ethereal solution of α gradually deposits a small quantity of a fourth resin, δ, reddish-brown colour. Analyses of two specimens of gum gave the following s (**Kopp**):

	I.	II.
Benzoic acid	14·0	14·5
Resin α	52·0	48 0
Resin β	25·0	28·0
Resin γ	3·0	3·5
Resin δ	0·8	0·5
Impurities	5·2	5·5

further states that the white spots in the gum are composed only of resin α, and n 8—12 per cent. benzoic acid; while the brown portions consist of resins β , and contain as much as 15 per cent. acid (18 per cent. according to Unverdorben). resin α is readily soluble in ether and alcohol, insoluble in naphtha; soluble in , and not reprecipitated by excess; insoluble in ammonia. Salts of the earthy vy metals give, in its alkaline solution, precipitates which are insoluble in ether. ding to Van der Vliet it is a mixture of resins β and γ, for it is decomposed into two resins by prolonged ebullition with sodic carbonate. Resin β is a brownish soluble in alcohol, insoluble in ether and volatile oils; soluble in potash, and re- pitated by excess; insoluble in ammonia. Resin γ is dark-brown, soluble in ol, slightly in ether and volatile oils, insoluble in naphtha. Potassic carbonate dissolves it, and the solution is precipitated by sal-ammoniac. Its alcoholic on precipitates acetate of lead, but not acetate of copper. Resins α and β, when pitated by acids from their alkaline solutions, are converted into γ by exposure to r.

e following are the results of the analysis of these resins, and the (unreliable) for- which Van der Vliet has deduced therefrom:

		V. d. V.		Mulder.	
Resin α	Carbon	72·9	71·8	73·1	$C^{35}H^{42}O^7 = \beta + \gamma$
	Hydrogen	7·2	7·1	7·3	
Resin β	Carbon	71·1	71·0	71·7	$C^{20}H^{21}O^{4\frac{1}{2}}$
	Hydrogen	6·2	6·3	6·9	
Resin γ	Carbon	73·2	73·2	73·2	$C^{15}H^{21}O^{2\frac{1}{2}}$
	Hydrogen	8·6	8·4	8·6	

the dry distillation of the resins of gum-benzoin, completely freed from benzoic Kopp obtained a solid substance, which he regards as the odorous principle of m, and a rose-red distillate, which gradually becomes darker, and contains crys- f benzoic acid; the fluid portion appears to be hydrate of phenyl. By the same s, Cahours obtained an oil, which Deville (Ann. Ch. Phys. [3] iii. 192) regards zoate of ethyl. When they are distilled to dryness, with excess of nitric acid, s fumes are abundantly evolved, and a distillate is obtained, containing hydride zoyl, benzoic acid, and hydrocyanic acid; boiling water extracts picric acid from sidue, and leaves a yellow powder, *benzoeretic acid* (*q. v.*) Sulphuric acid dis- the resins to a common solution, whence the addition of water separates them t completely as a violet precipitate; the acid liquid decanted and neutralised ime yields a soluble calcium-salt. F. T. C.

NZOLACTIC ACID. *Benzomilchsaure.* $C^{10}H^{10}O^4 = C^3H^4O.C^7H^5O.H.O^2$ loff and Strecker, Ann. Ch. Pharm. lxxx. 46. Strecker *ibid.* xci. 359).— acid is analogous to benzoglycollic acid, representing lactic acid in which 1 at. of sic hydrogen is replaced by benzoyl, just as benzoglycollic acid represents lic acid in which 1 at. of basic hydrogen is similarly replaced.

s prepared by heating 10 pts. of syrupy lactic acid with 14 pts. of benzoic acid oil-bath to 150° C., finally raising the temperature to 200°, and keeping it there me hours. Water distils over, and some benzoic acid sublimes. The residue in

the retort solidifies on cooling to a crytsalline mass of benzoic and benzolactic
These are separated by partial saturation with sodic carbonate, which takes u
benzolactic acid first; the solution is filtered from the benzoic acid, and freed
the small quantity of benzoic acid which it contains by agitation with ether; o
addition of hydrochloric acid, benzolactic acid separates in crystals, which are pu
by recrystallisation from boiling water, or from ether-alcohol.

It forms colourless tabular or spear-shaped crystals, unctuous to the touch: m
112° C., and solidifies very slowly on cooling to a crystalline mass; sublimes
composed when heated considerably above 120°. It dissolves in 400 pts. cold, a
much less boiling water: when boiled with not enough water to dissolve it
excess of acid melts and the solution becomes milky on cooling, and clarifie
slowly, with separation of crystals. It dissolves readily in alcohol or ether, the
removing it entirely from its aqueous solution; after drying in the air, it does no
any water when heated to melting. By prolonged boiling in water, it is decom
with benzoic and lactic acids: the decomposition is accelerated by the additio
dilute acid.

The *benzolactates* are mostly crystalline, soluble in water, and closely resembl
benzoates, from which, however, they are distinguished by their neutral solutio
being precipitated by normal acetate of lead. The *barium-salt*, $C^{20}H^{18}Ba''O^8$ +
crystallises in thin, shining, six-sided laminæ, which lose their water at 100° C.
silver-salt, $C^{10}H^9AgO^4$, is a flocculent precipitate, soluble in boiling water, whe
crystallises in fine needles. The *sodium-salt* crystallises in colourless needles
boiling alcohol.
F. T

BENZOLIC ALCOHOL. See Benzylene.

BENZOLINE. Syn. with Amarine (*q.v.*)

BENZOLONE. $C^{21}H^{15}O^2$ (?) (Rochleder, Ann. Ch. Pharm. xli. 94).—Fo
together with benzostilbin, when hydrobenzamide is heated with solid potash.
mixture must be heated till it blackens; the product is powdered, extracted with
washed with cold hydrated alcohol, and the residue dissolved in strong sulphuric
The blood-red solution thus formed becomes greenish-yellow on addition of
alcohol, and deposits small crystals of benzolone: on addition of water, it separa
the uncrystalline state. It is insoluble in water or alcohol; melts at 248° C
sublimes almost without decomposition, when more strongly heated. Strong
acid dissolves it with a reddish-yellow colour, and it is reprecipitated by water; fu
nitric acid decomposes it, forming a yellowish resin with evolution of nitrous f
It is not attacked by aqueous potash. Rochleder's analyses give a mean composit
C 83·5, H 5·2.
F. T.

BENZOMERCURAMIDE. See Benzamide.

BENZOMYRISTIC ANHYDRIDE. See Benzoic Anhydride.

BENZONE. *Benzophenone. Phenyl-benzoyl.* $C^{13}H^{10}O = C^6H^5.C^7H^5O$ (Pél
Ann. Ch. Phys. [2] lvi. 59. Chancel, Compt. rend. xviii. 83.; Ann. Ch. Ph
lxxx. 25).—The acetone of benzoic acid; it is formed by the dry distillation of ben
of calcium:

$$C^{14}H^{10}Ca''O^4 = C^{13}H^{10}O + CO^3Ca''.$$

Dry benzoate of calcium is mixed with $\frac{1}{10}$ of its weight of quick lime, and distill
an iron mercury bottle, fitted with a bent gun-barrel. The red liquid which p
over (which Péligot called benzone), contains,—besides benzone,—benzene, hydr
benzoyl, and two solid hydrocarbons isomeric with naphthalin. On distilling it
tubulated retort, benzene first passes over; and the temperature rises rapidly
portion which comes over at 315°—325° C. is collected apart, and consists of n
pure benzone, which solidifies on cooling, and may be obtained quite pure by recry
lisation from ether-alcohol. 1 kilogr. benzoate of calcium yields about 250
benzone.

Benzone forms colourless, transparent crystals, often of considerable size, belo
to the trimetric system. It melts at 46° C. to a thick oil which does not so
unless it be agitated; boils at 315° and distils undecomposed: its vapour is very in
mable, and burns with a bright flame. It has a pleasant smell, somewhat like th
benzoic ether. It is very soluble in ether, less so in alcohol, not at all in water; s
nitric or sulphuric acid dissolves it abundantly, and water reprecipitates it uncha
When heated with soda-lime to about 260° C. it is decomposed, yielding sodic ben
and benzene, but not a trace of hydrogen:

$$C^6H^5.C^7H^5O + NaHO = C^6H^5.H + C^7H^5O.Na.O.$$

Dinitrobenzone. *Dintrobenzophenone.* $C^{13}H^8N^2O^5 = C^{13}H^8(NO^2)^2O$.—Warm f

cid converts benzone into a thick oil, which solidifies very slowly; other dis-
it and deposits it speedily in the form of a yellowish crystalline powder, which
robenzone. Reducing agents convert it into diphenyl-carbamide (flavine):

$$C^{13}H^{8}N^{2}O^{5} + 6H^{2}S = \underset{\text{flavine.}}{C^{13}H^{12}N^{2}O} + 4H^{2}O + S^{6}.$$

he two hydrocarbons, isomeric with naphthalin, mentioned above, one cry-
s in large needles, fusible at 92° C., the other, much less soluble in alcohol
her, forms small nodules fusible at 65°. The former is readily obtained by
ing in strong sulphuric acid the liquid obtained by the dry distillation of
benzoate; it immediately solidifies on the surface, and is removed, washed, dried
r paper, and crystallised from hot alcohol. The latter is best prepared by the dry
tion of potassic benzoate with potash-lime: it then passes over alone, in solution
zol, which is distilled off in a water-bath, and the residue crystallised from
. It is also formed together with benzol, when ammonic benzoate is passed
eated baryta. F. T. C.

ZONITRILE. *Cyanide of Phenyl.* $C^7H^5N = C^6H^5.CN$ (Fehling (1844),
Ch. Pharm. xlix. 91. Limpricht and v. Uslar, *ibid.* lxxxviii. 133).—Ben-
e is obtained by various methods:—1. By the dry distillation of benzoate of
ium, or by heating benzamide, either alone or with caustic lime, or baryta,
oric anhydride, or perchloride of phosphorus: the reaction in all these cases
in the abstraction of the elements of water:

$$\underset{\text{Benz. amm.}}{C^7H^5O.NH^4.O} - 2H^2O = C^7H^5N.$$

$$\underset{\text{Benzamide.}}{N.C^7H^5O.H^2} - H^2O = C^7H^5N.$$

heating hippuric acid, either alone (Limpricht), or with chloride of zinc
mann). 3. By the action of chloride of benzoyl or benzoic anhydride on benza-
r by heating benzamide with potassium (see BENZAMIDE). 4. By the action of
e of benzoyl on oxamide (Chiozza):

$$C^7H^5O.Cl + N^2.C^2O^2.H^4 = C^7H^5N + CNH + HCl + CO^2 + H^2O.$$

sulphocyanate or cyanate of potassium (Schiff, Ann. Ch. Pharm. xcix. 117,
:

$$2C^7H^5O.Cl + 2CNSK = 2C^7H^5N + 2KCl + CO^2 + CS^2.$$

heating benzoic anhydride with cyanate or sulphocyanate of potassium (Schiff):

$$C^{14}H^{10}O^3 + 2CNOK = 2C^7H^5N + CO^3K^2 + CO^2.$$

the action of mercuric oxide on thiobenzamide (*q. v.* under BENZAMIDE).
aration.—1. When dry benzoate of ammonium is heated in a retort, ammonia
, benzoic acid sublimes, and water passes over with a few oily drops of benzo-
; as most of the benzonitrile remains in the fused residue in the retort, this is
d with water (to which a little ammonia is added), again distilled to dryness,
e operation repeated as long as any oil passes over with the water: 12 oz.
c acid yield in 5 days, 6 oz. impure benzonitrile. This product is washed with
hydrochloric acid, then with water, dried over chloride of calcium, and recti-
Fehling). According to Laurent and Chancel (Compt. chim. 1849, 117),
itrile is more easily prepared by passing the vapour of ammonic benzoate over
baryta.—2. One pt. dry hippuric acid is mixed in a warm mortar with an equal
f quartz-sand and 2 pts. chloride of zinc dried as completely as possible, and the
e is heated in a dry retort to 300°—350°C.: benzontrile then distils over, carbonic
ride escapes, and a little carbon is deposited; 100 grms. hippuric acid (the utmost
tions being taken to exclude moisture) yielded 33—40 grms. benzonitrile;
tion requires 57 grm. (Gössmann, Ann. Ch. Pharm. c. 72).—3. According to
on and Hofmann, benzonitrile is best prepared by distilling benzamide with
oric anhydride.
zonitrile is a clear, colourless, strongly refracting oil, smelling like bitter-almond
d having a burning taste; specific gravity 1·0230 at 0°, 1·0084 at 16·8° C.
). At higher temperatures it is less dense than water, for it sinks in cold water,
es to the surface when heated. It boils at 190·6° C. with the barometer
·4 mm. (Kopp), and distils undecomposed: its vapour density is 3·7 (expt.);
fficient of refraction is 1·503 (Reusch). It dissolves in 100 pts. boiling
and separates out again on cooling; it mixes with alcohol and ether in all
tions. Sulphur dissolves in it with the aid of heat, and crystallises out on
.

Benzonitrile burns with a bright smoky flame. Cold *aqueous potash* doe attack it, but on boiling, ammonia is evolved and potassic benzoate formed; a s decomposition is effected by dilute acids. Strong *sulphuric acid* dissolves it, a heating, sulphobenzoic and disulphobenzolic acids, and acid sulphate of amm are formed, and carbonic anhydride is evolved: (Buckton and Hofmann):

$$2C^7H^5N + 5SO^4H^2 + H^2O = C^7H^6SO^5 + C^6H^6S^2O^6 + 2(NH^4.H.SO^4.) +$$

With fuming *nitric acid* it forms a substitution-product (see below); when with potassium in a sealed tube, it assumes a carmine colour, and at 240° C. y sublimate of fine needles; water extracts cyanide of potassium from the produc the residue yields on distillation, a green oil smelling of creosote, in which c again form (Bingley, Chem. Gaz. 1854, 329). With *sulphide of ammonium*, it *thiobenzamide* (*q. v.* under BENZAMIDE).

Substitution-products of Benzonitrile.

Chlorobenzonitrile or *Cyanide of Chlorophenyl*, C^7H^4ClN, has not been ob by the action of chlorine on benzonitrile; but it is the principal product when s benzamide or sulphobenzamic acid is distilled with perchloride of phosphorus. distillate is mixed with potash, and rectified, when chlorobenzonitrile passes ove aqueous vapour, and collects in the receiver, forming crystals which are obtained i colourless prisms by recrystallisation from alcohol or ether. It smells like bitter-a oil, is insoluble in water, but readily soluble in alcohol or ether; melts below 40 solidifies at 36° C., volatilises slightly at the ordinary temperature, more rapi a gentle heat. Prolonged boiling with dilute nitric acid converts it into chlorob acid; heated to 100° with ammonia in a sealed tube, it yields chlorobenz (Limpricht.)

Nitrobenzonitrile or *Cyanide of Nitrophenyl*. $C^7H^4N^2O^2 = C^6H^4(NO^2)N$.- cipitated as a white solid body when benzonitrile is heated gently with fuming acid and water added to the solution; it is tolerably soluble in hot water, and rates on cooling in small white silky needles, soluble in acids, and reprecipitat water. When heated, it evolves irritating vapours, and leaves a residue of c When boiled with acids or alkalis, it yields ammonia and a nitrobenzoate. It can obtained by the dry distillation of nitrobenzoate of ammonium (Gerland). F. T

BENZONITROBENZOIC ANHYDRIDE. See BENZOIC ANHYDRIDE.

BENZONITROCUMIDE. See CUMYLAMINE.

BENZOŒNANTHYLIC ANHYDRIDE. See BENZOIC ANHYDRIDE.

BENZOPELARGONIC ANHYDRIDE. See BENZOIC ANHYDRIDE.

BENZOPHENIDE. Syn. with BENZOATE OF PHENYL. See BENZOIC ACID.

BENZOPHENONE. Syn. with BENZONE (*q. v.*)

BENZOPIPERIDE. See PIPERIDINE.

BENZOPROPYLENYL. Syn. with BENZOATE OF ALLYL. See BENZOIC A

BENZOSALICIN. Syn. with POPULIN (*q. v.*)

BENZOSALICYLAMIC ACID. *Benzosalicylamide.* $C^{14}H^{11}NO^3 = N.H.C$ $C^7H^4O.H.O.$ (Gerhardt and Chiozza, Compt. rend. **xxxvii.** 86; Limpricht Ch. Pharm. **xciv.** 249.)—When equivalent quantities of salicylamic acid and chlo benzoyl are heated together to 120—145° C., as long as hydrochloric acid escap product remains liquid a long time after cooling, but crystallises on adding a few d alcohol or ether; it is washed with ether, and dissolved in boiling alcohol, whe crystallises in slender needles united in flocks. It is sparingly soluble in a even on boiling. When heated, it gives off water, and is converted into salicylimide. It is readily soluble in ammonia, and is reprecipitated unch on evaporating the solution, or on addition of an acid. It dissolves in the alkalis, forming deep yellow solutions, but is generally decomposed into benzoat salicylate. It is attacked by chloride of benzoyl, yielding a crystalline p which appears to be converted into benzosalicylamic acid by the addition of w alcohol. After fusion, it is no longer completely soluble in hot ammonia; the residue is soluble in alcohol, forming a yellow solution which deposits on ev tion small crystals, apparently of an ammonium-salt: the solution is decoloris hydrochloric acid.

Benzosalicylamates.—The ammoniacal solution of the acid forms a light-yello cipitate with normal acetate of lead, and a light-blue with sulphate of copper. nitrate of silver, it forms the *silver-salt*, $C^{14}H^{10}AgNO^3$, a yellow precipitate, becomes heated on contact with chloride of benzoyl, forming a viscous product, dissolves in alcohol, leaving a residue of chloride of silver.

ic acid be regarded as monobasic, this compound becomes *benzosalicylamide*,
$H^4O.^2H$. F. T. C.

SALICYLAMIDE. See Benzosalicylamic Acid.

SALICYLIC ACID. $C^{14}H^{10}O^4 = C^7H^4O.C^7H^5O.H.O^2$. (Gerhardt
. Ch. Phys. [3] xxxvii. 322.)—Formed by the action of chloride of benzoyl
e of potassium, as a viscous mass difficult to purify, soluble in ether, de-
y boiling water into benzoic and salicylic acids. By dry distillation, it
ate of phenyl, and other products soluble in potash.
pound is analogous to benzoglycollic and benzolactic acids. If salicylic acid
as monobasic, it becomes benzosalicylic anhydride, $C^7H^5O.C^7H^4O^2.O$.
F. T. C.

SALICYLIMIDE. See Benzamide.

STEARIC ANHYDRIDE. See Benzoic Anhydride.

STILBIN. $C^{14}H^{10}O$ (?) (Rochleder, Ann. Ch. Pharm. xli. 93).—The
der obtained by fusing hydrobenzamide with solid potash consists of a
three substances, a peculiar yellow oil, benzostilbin, and benzolone: the pro-
these three compounds vary with the duration of the fusion, benzolone not
d at all unless the mixture has been heated till it blackens. The two former
d from the third by alcohol, in which benzolone is insoluble. The alcoholic
nixed with a little hydrochloric acid, when it becomes red, but is decolo-
nding, and deposits benzostilbin in small crystals; the same result is pro-
rapidly by passing chlorine into the solution. The crystals may be
ger by the slow evaporation of their solution in ether. When quite free
llow oil, they are but slightly soluble in alcohol. They melt at 244·5° C.,
when further heated, being in great measure decomposed. They dissolve
colour in sulphuric acid, and may be boiled without decomposition in
ash of 1·2 specific gravity. Rochleder's analysis gives 86·5—86·6 C,
F. T. C.

SUCCININ. $C^{14}H^{12}O^6$. — The name given by Van Bemmelen (J. pr.
84) to a glyceride or artificial fat obtained by heating glycerin to 200° C.
and succinic acids. It is a soft dark-brown mass, which is decomposed by
with water or alcohol, more rapidly in presence of an alkali, into benzoate
te. It represents glycerin in which 1 at. H is replaced by benzoyl and
cinyl, $C^3H^4(C^7H^5O)(C^4H^4O^2)O^3$. F. T. C.

SULPHOPHENAMIC ACID. See Benzamide.

SULPHOPHENAMIDE. See Benzamide

SULPHOPHENAMIDYL, Chloride, and Amide. See Benzamide.

SULPHOPHENARGENTAMIDE. See Benzamide.

SULPHOPHENYLSODAMIDE. See Benzamide.

SYLANILIDE. See Benzylene-phenylamine.

TARTARIC ACID. $C^{11}H^{10}O^7 = (C^4HO^4)''.C^7H^5O.H.O^2$. (Dessaignes,
. [3] xxxii. 47.)—Obtained by heating a mixture of equivalent quantities
tartaric acids to 150° C. The acids melt at first without mixing, but at
homogeneous brown mass. When this is dissolved in boiling water, some
crystallises out; the mother-liquor is partially neutralised by sodic carbo-
rised by animal charcoal, and acidulated with hydrochloric acid. After
nodular masses separate out, which are formed of microscopic crystals, and
ed in form by recrystallisation. The acid is more soluble in cold water
acid, but less soluble in alcohol; its solution has no smell. No sublimate
hen it is heated to the melting-point of benzoic acid; when it is further
zoic acid sublimes, and the brown residue smells of heated tartaric acid.
rated solution of the acid does not precipitate lime-water, ferric chloride,
silver; it slightly precipitates a concentrated solution of normal acetate
hen neutralised with ammonia, it gives a pale yellow precipitate with ferric
does not precipitate chloride of calcium. When its solution is one-fourth
with ammonia, it gives with nitrate of silver, a precipitate, which at first
ed: it contains 46·35 per cent. silver, corresponding to the formula
From this the acid would appear to be dibasic, in which case it is not
benzoglycollic and benzolactic acids. F. T. C.

VALERIC ANHYDRIDE. See Benzoic Anhydride.

YL. C^7H^5O.—The hypothetical radicle which, according to Liebig and

Wöhler's original suggestion, is usually considered as existing in benzoic aci many of its kindred compounds,—benzoic acid, $C^7H^6O^2$, being regarded as hydr benzoyl, $C^7H^5O.H.O$, bitter-almond oil, C^7H^6O, as hydride of benzoyl, &c. Thi explains the reactions of the majority of benzoyl-compounds in a far more satisf manner than that of Berzelius, who, in accordance with his opinion that oxygen entered into the composition of an organic radicle, considered C^7H^5 as the radi this group of compounds. The readiness with which many benzoyl-compound into phenyl-compounds renders it probable that benzoyl should be regarded compound of phenyl, C^6H^5, with carbonyl, CO; just as acetyl may be regarde compound of methyl and carbonyl. One or more atoms of hydrogen in benz capable of being replaced by a monatomic radicle (Cl, Br, NO^2, &c.) forming may be called secondary or substitution-radicles (chlorobenzoyl, C^7H^4ClO, nitrob $C^7H^4(NO^2)O$, &c.), which may be supposed to exist in chloro- or nitro-benzoic ac Benzoyl has not yet been isolated. Benzil, which has the same composition, do exhibit any analogy with other organic radicles. F. T

BENZOYL, BROMIDE OF. *Brombenzaldid.* $C^7H^5O.Br$. (**Liebig** and **Wö** Ann. Ch. Pharm. iii. 266.)—When hydride of benzoyl is mixed with bromine, evolved, and hydrobromic acid given off: the mixture is then heated, to free it pletely from hydrobromic acid and excess of bromine. Thus obtained, brom benzoyl is a soft, brown, broadly laminar, crystalline mass, semifluid at the or temperature, and melting at a very gentle heat to a brownish-yellow liquid. a faint aromatic odour, somewhat like that of chloride of benzoyl, and is readily s without decomposition, in alcohol and ether. When heated with water, it melt remains at the bottom, as a brownish oil, which is decomposed into benzoi hydrobromic acids only by prolonged boiling. It fumes slightly in the air, st when heated, and burns with a bright sooty flame. F. T

BENZOYL, CHLORIDE OF. *Chlorbenzaldid.* $C^7H^5O.Cl$. (Liebig Wöhler (1832), Ann. Ch. Pharm. iii. 262; Cahours, Ann. Ch. Phys. [3] 334; Gerhardt, *ibid.* xxxvii. 291).—Formed: 1. by the action of chlori hydride of benzoyl (L. and W.)—2. By heating perchloride of phosphorus benzoic acid (Cahours).—3. By the action of oxychloride of phosphorus on ben (Gerhardt). Also in small quantities, by the action of chlorine on mandelic or on benzoate of methyl or ethyl (Malaguti, Ann. Ch. Phys. [2] lxx. 374), a cinnamein (Fremy, *ibid.* 180).—4. By heating benzoic acid to 200° C. with a m of chloride of sodium and anhydrous acid sulphate of sodium or potassium.

Preparation.—1. Dry chlorine is passed into hydride of benzoyl, the liquid gradually heated to boiling, till no more hydrochloric acid is evolved: the prod freed by heat from dissolved chlorine.—2. A better and easier method is to warm valent proportions of benzoic acid (122 pts.) and perchloride of phosphorus (20 in a tubulated retort; a violent reaction takes place, hydrochloric acid is evolve a mixture of chlorides of benzoyl and phosphoryl distils over, heat being gra applied. The mixed chlorides are separated by fractional distillation: at 110° C., ch of phosphoryl passes over; from 110° to 196°, a mixture of the two chlorides; an 196° to 200°, nearly pure chloride of benzoyl, which is readily freed from traces o chloride by washing with water, and dried over chloride of calcium.—3. Sodic zoate is treated in a similar manner with oxychloride of phosphorus: the react violent even in the cold, and if the oxychloride be slightly in excess, chlor benzoyl and sodic phosphate are the only products:

$$3C^7H^5NaO^2 + POCl^3 = 3C^7H^5O.Cl + PO^4Na^3,$$

otherwise benzoic anhydride is also formed. The distillate below 196° obtained may advantageously be employed for this purpose.

Chloride of benzoyl is a clear colourless liquid, with a peculiar smell, which bles that of horse-radish and makes the eyes water. Specific gravity 1·196 (L W.); 1·25 at 15° C. (Cahours): boils at 196°: vapour-density (expt.) (Cahours); 4·901 (calc.). It is insoluble in water, but is decomposed slowly by and quickly by hot water, into benzoic and hydrochloric acid: the same deco tion is slowly effected when it is exposed to moist air. It is decomposed by a with evolution of heat, into benzoic ether and hydrochloric acid: it does n upon pure ether. It is soluble in all proportions in bisulphide of carbon, w decomposition, and with the aid of heat dissolves sulphur and phosphorus, crystallise out on cooling.

It burns with a bright, green-edged, very smoky flame. When boiled with a *alkalis*, it is immediately decomposed into benzoate and chloride, but it m distilled without alteration over anhydrous lime or baryta. With dry *ammonia* o *monic carbonate*, it forms benzamide and chloride of ammonium; it is similarly d

enylamine and other alkaloids, yielding phenylbenzamide, &c. It is decom-
rtain metallic *bromides*, *iodides*, *sulphides*, and *cyanides*, yielding bromide,
hide, or cyanide of benzoyl. With *sulphocyanate of potassium*, it evolves
yields carbonic anhydride and sulphide, and benzonitrile (Schiff, Ann.
xcix. 117): probably owing to the decomposition of sulphocyanate of

$$2(CNS.C^7H^5O) = 2C^7H^5N + CO^2 + CS^2$$ (Limpricht).

tacked by *potassium*. When heated with *hydride of copper*, it yields
enzoyl and subchloride of copper (Chiozza). With *chloride of aluminium*,
rystalline compound, but not with the chlorides of copper, magnesium, or
ecomposed by *perchloride of tin* (Casselmann). With the alkaline salts
ganic monobasic acids, it yields an alkaline chloride and an anhydride,
dic benzoate, benzoic anhydride; with *sodic pelargonate*, benzopelargonic
&c. (Gerhardt). Heated with *formate of sodium*, it yields carboni
ide of sodium, and benzoic acid:

$$CHNaO^2 + C^7H^5OCl = CO + NaCl + C^7H^6O^2$$ (Gerhardt).

h *potassic oxalate*, it yields benzoic anhydride, potassic chloride, and car-
and anhydride (Gerhardt) with *oxamide*, benzonitrile and other products
ITRIL), with most *amides*, a secondary or tertiary amide containing benzoyl.
ely powdered *aldehyde-ammonia* is gradually added to chloride of benzoyl,
ac and benzoic acid are formed, together with a substance which crystal-
ot alcohol in needles having the composition $C^{16}H^{16}N^2O^2$, isomeric (perhaps
ith hipparaffin. It is insoluble in water, readily soluble in hot alcohol or
sible, and sublimes partly undecomposed; is slowly decomposed by boiling
lphuric acid into benzoic acid and a brown resin; is not attacked by boiling
and peroxide of lead, till sulphuric acid is added, when aldehyde is evolved
ide formed; is similarly decomposed by nitrous acid. (Limpricht, Ann.
xcix. 119.)

ride of phosphorus dissolves in hot chloride of benzoyl, and is deposited on
erhardt). According to Schischkoff and Rosing (Compt. rend. xlvi.
equivalent quantities of the two substances are heated together in a sealed
° C. for some days, a compound, $C^7H^5Cl^3$, is formed, which they call *per-
benzoyl*. The contents of the tube are heated in a retort to about 110° C.,
t with strong potash, and then with water, and dissolved in alcohol; the
water precipitates the compound as a yellowish neutral oil, heavier than
ble in alcohol or ether. It blackens at 130°—140°, and cannot be distilled
omposition. It is decomposed when heated with water in a sealed tube, but
e contact with water or aqueous or solid potash: it is also decomposed by
ic acid, evolving nitrous fumes; with acetate of silver in the cold it yields
silver.

tion of chlorine on benzoate of ethyl (*q. v.*) a compound is obtained, having
ition $C^{18}H^{16}Cl^6O^3$, which may be regarded as a compound of chloride of
th tetrachlorovinic ether, $C^{18}H^{16}Cl^6O^3 = 2C^7H^5OCl.C^4H^6Cl^4O$. It is a
quid, boiling at 188°—190° C., of specific gravity 1·346 at 10·8°, smells like
benzoyl, fumes in moist air, and is slowly decomposed by water into hydro-
zoic, and acetic acids. (Malaguti, Ann. Ch. Phys. [2] lxx. 374.)

of benzoyl appears to form a compound with hydride of benzoyl. (See
HYDRIDE OF.)

Substitution-products of Chloride of Benzoyl.

le of Chlorobenzoyl. $C^7H^4Cl^2O = C^7H^4ClO.Cl$. (Limpricht and v.
n. Ch. Pharm. cii. 262).—Obtained: 1. By the action of perchloride of
on chlorobenzoic acid.—2. By the decomposition of sulphobenzoic

$$C^7H^4Cl^2SO^3 = C^7H^4Cl^2O + SO^2.$$

benzoic acid is heated with 2 at. perchloride of phosphorus, as long as any-
s over; by repeated rectification of the distillate, a yellowish liquid is ob-
ch boils at 285° C., and consists of impure chloride of chlorobenzoyl, which
purified by distillation. As obtained by (1) it is a clear, colourless, strongly-
liquid, which boils at 225° C.: is slowly decomposed by boiling water into
oic and hydrochloric acids, and quickly by strong aqueous ammonia, into
amide and chloride of ammonium.

istillation of salicylic acid with perchloride of phosphorus Chiozza (Ann.

Ch. Phys. [3] xxxvi. 102) obtained a compound isomeric with the foregoing,
may be called *chloride of parachlorobenzoyl:*

$$C^7H^6O^3 + 2PCl^5 = C^7H^4Cl^2O + 2POCl^3 + 2HCl.$$

The distillate, which is probably not quite pure, is a heavy strongly-refracting
with a suffocating smell, and decomposed slowly by cold, immediately by hot
into parachlorobenzoic and hydrochloric acids: when gently heated with sal
acid, it yields hydrochloric acid and salicylide of benzoyl. This reaction has
been explained.

Chloride of ***Nitrobenzoyl.*** $C^7H^4ClNO^3 = C^7H^4(NO^2)O.Cl.$ (Cahours
Ann. Ch. Phys. [3] xxiii. 339; Bertagnini, *ibid.* [3] xxxiii. 465.)—Formed
action of chlorine in the sunshine on hydride of nitrobenzoyl. Also by heating
benzoic acid with perchloride of phosphorus; a mixture of the chlorides of pho
and nitrobenzoyl distils over, which is rectified, and the portion which pass
last, is washed with water, dried over chloride of calcium, and again distilled.
yellow liquid, heavier than, and insoluble in, water, something like chloride of b
and boiling at 265°—268° C. It is gradually decomposed in moist air into nit
zoic and hydrochloric acids. It is similarly decomposed by strong boiling potash.
ammonia, it forms nitrobenzamide; with phenylamine, phenylnitrobenzamide.
alcohol or wood-spirit, it forms nitrobenzoate of ethyl or methyl: it is not decor
by ether.
F.

BENZOYL, CYANIDE OF. $C^8H^5NO = C^7H^5O.CN.$ (Liebig and Wöhler
Ann. Ch. Pharm. iii. 267; H. Strecker, *ibid.* xc. 62.)—When chloride of benzoy
tilled with cyanide of mercury, a yellow oil passes over, which may be obtained
less by rectification (L. and W.); after a time, it solidifies to a crystalline mass,
after washing with water as long as any mercury-salt is washed out, and dryin
filter-paper and over sulphuric acid, leaves pure cyanide of benzoyl. It is a col
crystalline body, which melts at 31° C., and crystallises by slow cooling in tal
inch long; it has a pungent odour, exciting tears; boils at 206°—208° C.; is heavi
water; is inflammable, and burns with a very smoky flame. It is very slowly
posed by water in the cold, and not rapidly, even on heating: is decomposed by a
potash; also by ammonia, into benzamide and cyanide of ammonium; and by zi
hydrochloric acid, into hydride of benzoyl and benzoin.
F.

BENZOYL, HYDRIDE OF. *Benzaldine. Bitter-Almond Oil. Ox
Picramyl. Oxide of Stilbene.* $C^7H^6O = C^7H^5O.H.$ (Liebig and Wöhler
Ann. Ch. Pharm. xxii. 1.)—The principal constituent of crude bitter-almond oil,
latile oil which is obtained by distilling bitter-almonds with water (see BITTER-A
OIL). It is also formed by the decomposition of many organic substances. 1.
oxidation of amygdalin, amygdalic acid, benzylic alcohol (Cannizzaro, An
Pharm. lxxxviii. 180), cinnamon-oil, cinnamic acid (Mulder, Dumas, and Pé
and gum-benzoin, by nitric acid; of stilbene and styracene by aqueous chrom
(Laurent); of mandelic acid, styrone, and (with several other products) of cas
bumin, fibrin, and gelatine, by sulphuric acid and binoxide of manganese.—2.
action of hydride of copper on chloride of benzoyl (Chiozza, Compt. rend. xxxv
—3. By the rapid dry distillation of a mixture of benzoate and formate of calc

$$(C^7H^5O^2)^2Ca + (CHO^2)^2Ca = 2CO^3Ca + 2C^7H^6O$$

a brown oily liquid passes over, whence hydride of benzoyl is separated by a
phite of ammonium (Piria, Ann. Ch. Pharm. c. 104).—4. By the action of
hydrogen on cyanide of benzoyl. Cyanide of benzoyl is heated gently with
chloric acid and excess of zinc; the cyanide turns yellow, and the zinc becomes
with an unctuous mass, containing hydride of benzoyl, hydrocyanic acid, and h
This, when heated with potash, yields reddish-yellow oily drops, which, when di
yield pure hydride of benzoyl (Kolbe, Ann. Ch. Pharm. xcviii. 344).—5. By
tion of oxalate of silver on chloride of benzylene,

$$C^7H^6Cl^2 + C^2Ag^2O^4 = C^7H^6O + CO^2 + CO + 2AgCl.$$

The mixture must be very cautiously heated under rock-oil, otherwise a
reaction takes place, attended with complete destruction of the organic com
(Golowkinsky, Ann. Ch. Pharm. cxi. 252.)

Crude bitter-almond oil contains, besides hydride of benzoyl, hydrocyanic an
zoic acids, benzoin, and benzimide. By submitting the oil to fractional disti
hydrocyanic acid first passes over, and then tolerably pure hydride of benzo
other compounds remain in the residue. Pure hydride of benzoyl may also
tained from the crude oil by several chemical means: 1. By agitating the o
powdered mercuric oxide and water (v. Ittner), or with milk of lime and
chloride of iron (W. and L.), and distilling.—2. By agitating the oil with three

ne of acid sulphite of sodium of 27° B., or 1·231 specific gravity; dry-
, or on a porous tile, the crystalline mass which forms after some
g it with cold alcohol; dissolving it in the smallest possible quantity of
omposing it by a strong solution of sodic carbonate. The oil which
canted and distilled over chloride of calcium (Bertagnini, Ann. Ch.
186). According to Müller and Limpricht (Ann. Ch. Pharm. cxi.
ssary, in order to obtain a pure product by this method, either to re-
crystalline compound before distilling it with carbonate of sodium, or
quid which passes over; the portion which distils up to 184° C. is then
ocyanic acid.

e of benzoyl is a colourless, limpid, strongly-refracting liquid, with a
ng that of oil of bitter-almonds, and a burning aromatic taste. Its
is 1·0499 at 14·6 or 1·063 at 0° C. (Kopp); boils at 179·1° with the
51·3 mm.; vapour-density (calc.) 3·66. It is soluble in 30 pts. water.
portions in alcohol and ether; when free from prussic acid, it is not
the animal organism it is converted into hippuric acid (Wöhler and
n. Ch. Pharm. lxvi. 336). It dissolves in sulphurous acid more easily
and separates out on evaporating the solution. It is generally regarded
of the benzoic group, since it exhibits many of the reactions of an alde-
g with acid sulphites of alkali-metals, and oxidising in moist air to
ut it does not reduce silver-solutions.

a bright very smoky flame. It may be passed through a tube heated to
thout decomposition; but if the tube be filled with fragments of pumice-
omposed into benzoyl and carbonic oxide (Barreswil and Boudault,
v. 267). Heated to 100° C. in a sealed tube with ferric hydrate (pre-
t 100°) it is oxidised, and yields a considerable quantity of ferrous ben-
the non-combined ferric oxide being also reduced to ferrous oxide
. Ch. Pharm. cxi. 124). Dry *chlorine* converts it into chloride of ben-
chloric acid; this decomposition is seldom complete, especially if the
compound of chloride and hydride of benzoyl being formed (see below).
rts it into bromide of benzoyl and hydrobromic acid. *Iodine* does not
d strong *nitric acid* dissolves it undecomposed, and on heating, slowly
benzoic acid: fuming nitric acid, or nitrosulphuric acid, converts it into
robenzoyl (see below). Strong *sulphuric acid* dissolves it, forming a
hich blackens and gives off sulphurous anhydride when heated. With
dride it forms a sulpho-conjugated acid, sulphomandelic acid (Mits-
rb. 4^{te} Aufl. i. 163). With *perchloride of phosphorus*, it yields the chlo-
ene and phosphoryl (Cahours, Compt. rend. xxv. 725). Heated with
yl in equivalent proportions for several hours to 120°—130° C. in a sealed
s hydrochloric and cinnamic acids (Bertagnini, Ann. Ch. Pharm.

$$C^7H^6O + C^2H^3O.Cl = C^9H^8O^2 + HCl.$$

ic acid or *sulphide of ammonium*, it yields peculiar products containing
arying according to the amount of alkali present, and the medium in
ride of benzoyl is dissolved. In an alcoholic solution, it yields hydride
(see below); in an ethereal solution, *thiobenzaldine*. With *ammonia*
f carbon it yields *sulphocyanobenzylene*. It dissolves *potassium*, becom-
dark, but without evolution of hydrogen (Löwig). When heated with
evolves hydrogen, and is converted into benzoate; with alcoholic potash,
and benzylic alcohol. *Cyanide of potassium* converts it into benzoin.
it forms various products (Laurent); with *aqueous* ammonia hydro-
and azobenzoilide; with *alcoholic* ammonia amarine, benzimic-
netimes, dibenzoylimide (Robson). With *aniline*, it yields ben-
nylamine; with *urea*, benzoyluride.

s. *Benzoate of Hydride of Benzoyl.* See BITTER-ALMOND OIL.

Benzoyl with Chloride of Benzoyl. $C^{14}H^{11}ClO^2 = C^7H^6O.C^7H^5OCl$
d Gerhardt, Compt. chim. 1850, p. 123.)—Formed abundantly when
nzoyl is imperfectly saturated with chlorine, or even when it is treated
chlorine. The saturated solution, when left to itself in a stoppered
lly solidifies into a crystalline mass, which is washed with cold alcohol,
forms colourless shining laminæ, resembling benzoic acid; melts very
mains liquid a long time when at rest; heated above its melting point it
ide of benzoyl. When dry, it is inodorous, but if moist it gives off fumes
c acid, and smells of hydride of benzoyl. Hot water decomposes it into
hydrochloric acids, and hydride of benzoyl. It is insoluble in cold
n alcohol decomposes it. It is decomposed by strong sulphuric acid.

Hydrocyanate of Hydride of Benzoyl. $C^8H^7NO = C^7H^6O.CNH$ (V (1844), Pogg. Ann. lxii. 444).—When crude bitter-almond oil or bitter-almon is mixed with hydrochloric acid, and evaporated below 100° C., till it is cons concentrated, this compound separates as a yellowish oil, which is washed wit and dried over sulphuric acid in vacuo. It is inodorous; boils at 170° C. gravity 1·24. Slightly soluble in water, forming a bitter or neutral solution. in alcohol or ether. It begins to decompose at 100° C., and when boiled is resolved into hydride of benzoyl and hydrocyanic acid; it is similarly dec by aqueous potash. When evaporated with strong hydrochloric acid, it takes and forms mandelic acid and ammonia:

$$C^8H^7NO + 2H^2O = C^8H^8O^3 + NH^3.$$

Gerhardt (Traité, iii. 193) mentions a compound obtained by distilling in bath, a mixture of 2 pts. hydride of benzoyl, 1 pt. cyanide of mercury, and drochloric acid; it is an oil which smells like hydride of benzoyl, has a specifi of 1·10; is somewhat soluble in water, more in alcohol, readily in ether; does no at 12° C.; boils at 312°, yielding a distillate which crystallises on cooling.

Hydride of Benzoyl with Chloride of Calcium.—When dry p chloride of calcium is added to anhydrous bitter-almond oil, heat is evolve solid compound is formed, which separates from the liquid in easily deco crystals, apparently containing 2·5 to 3·3 at. $CaCl^2$ to 2 at. hydride of benzoy mann, Ann. Ch. Pharm. cxii. 151.)

Hydride of Benzoyl with Acid Sulphites of Alkali-metals. (Bert Ann. Ch. Pharm. lxxxv. 183.)

a. With Acid Sulphite of Ammonium.—Hydride of benzoyl dissolves in al tions in acid sulphite of ammonium; but the resulting compound cannot be ob the crystalline state. The solution dissolves an excess of hydride of benzoy separates out on addition of water. Ammonia renders it turbid, and gradual pitates a body having the properties of hydrobenzamide. When the dry com heated with excess of slaked lime, it yields amarine and lophine. (Gössma

b. With Acid Sulphite of Potassium.—When hydride of benzoyl is shaken solution of this salt of 28°—30° Baumé (specific gravity 1·24—1·26), a crystallin is speedily formed, which must be dried with filter-paper, and dissolved in dilu alcohol (if boiled too long decomposition takes place); the solution on cooling the compound in shining rectangular laminæ. It is very soluble in water, l presence of alkaline sulphites, not at all in a saturated solution of these sal ingly soluble in cold, readily in boiling, alcohol. It is permanent in the aqueous solution is decomposed by boiling, either alone or with dilute acid alkaline carbonates, with separation of hydride of benzoyl.

c. With Acid Sulphite of Sodium. $C^7H^6O.SO^3NaH$. ½ Aq.—Formed like (*b* white aggregated prisms, tasting of hydride of benzoyl and sulphurous aci soluble in water, sparingly in hot alcohol, insoluble in cold alcohol. It ma in stoppered bottles, and decomposes but slowly when exposed to the air. W fully heated in the air, it is decomposed without blackening, into sulphurous a and hydride of benzoyl, sulphite of sodium remaining; in a stream of hydr decomposition takes place below 100° C. Its aqueous solution is decompose ing, either alone or with acids or alkalis, like that of (*b*), also by iodine or chlor sulphate being formed. Nitric acid decomposes the dry salt in a similar man aqueous solution gives, with barium-salts, a white precipitate, soluble in hyd acid; it also precipitates lead- and silver-salts: the precipitates appear to portion of the oil.

Substitution-products of Hydride of Benzoyl.

Hydride of Nitrobenzoyl. Nitrobenzaldide. $C^7H^5NO^3 = C^7H^4(NO^2)O$. tagnini, Ann. Ch. Pharm. lxxix. 259; lxxxvi. 190.)—When hydride of benzo dually added to fuming nitric acid, or to 15—20 vols. of a mixture of 1 vol. n 2 vols. sulphuric acid, heat is evolved, and the addition of water precipitates h nitrobenzoyl in yellowish oily drops, which crystallise in a few days. The ve be kept cool during the operation, otherwise nitrobenzoic acid will be forme crystals are contaminated by a yellow fetid oil, whence they are purified by pre tween filter-paper, and recrystallisation from boiling dilute alcohol.

It forms white shining needles, inodorous when pure, with a taste like th dride of benzoyl. It is slightly soluble in cold, readily in hot water or alc so in ether; dissolves undecomposed in nitric, hydrochloric, or sulphuric ac crystallises out as the last solution absorbs moisture from the air. It melts a colourless liquid, which solidifies at 46° C.; when further heated, it gives off

nell pleasantly when dilute, but are very pungent when concentrated. It may
lised in small quantities without decomposition; partly even when boiled with
ompletely when heated in an oil-bath in a stream of gas.
de of nitrobenzoyl burns with a smoky flame. It does not absorb oxygen from
but is readily converted into nitrobenzoic acid by oxidising agents, *e. g.*
chromic acid, or a mixture of nitric and sulphuric acids. *Chlorine* in sunshine
it into *chloride of nitrobenzoyl* (see BENZOYL, CHLORIDE OF). *Bromine* dis-
adily in fused hydride of nitrobenzoyl, but does not decompose it till heated
° C., when a brown resinous mass is formed. Strong *hydrocyanic acid* readily
it, the solution, if evaporated at once, deposits it unaltered, but after stand-
few hours, yields on evaporation, a viscid liquid, permanent in the air, soluble
ater, and separating out on cooling, which, when boiled with hydrochloric acid,
loride of ammonium, and another body soluble in water. *Cyanide of potas-*
composes it at once, forming compounds which have not been examined.
lphydric acid, its alcoholic solution forms *hydride of thionitrobenzylene*
ow). When its solution in alcoholic ammonia is treated with sulphuretted
, a semifluid mass is deposited, which consists of a sulphur-compound mixed
sulphur; the former is dissolved out by ether, and obtained by evaporation as
reddish liquid, insoluble in water or dilute acids, soluble in warm alcohol; it
posed by heat, evolving sulphuretted hydrogen, and when boiled with nitric
ms sulphuric acid and a yellow resin. Heated with *sulphite of ammonium*
an acid product, readily soluble in water or alcohol. *Alcoholic potash*
it into nitrobenzoate in the cold; *aqueous potash* requires the aid of heat.
a, whether dry, aqueous, or alcoholic, converts it into trinitrohydrobenzamide.
is gently heated with *urea*, water is given off, and the whole solidifies on cooling
opaque mass (nitrobenzoylureid?) slightly soluble in alcohol, readily in alcohol
ng hydrochloric acid, being thereby decomposed into urea and hydride of
zoyl.

de of nitrobenzoyl combines with acid sulphites of alkali-metals, forming com-
of which the following have been examined:

th Acid Sulphite of Ammonium. $C^7H^5NO^3.SO^3NH^4 + \frac{1}{2}$ Aq.—Hydride of
zoyl is dissolved in a solution of acid sulphite of ammonium of 29° Bm. at a
eat, when this compound crystallises out on cooling. It forms small, tran-
colourless prisms, which grate between the teeth, and have a bitter and sul-
taste; are soluble in water or boiling alcohol, and crystallise readily from the
lution only. It is permanent in the air, though it gradually acquires a violet
Its aqueous solution is decomposed by boiling, either alone or with acids or
With bárium- lead- or silver-salts, its aqueous solution gives a precipitate of
sulphite mixed with hydride of nitrobenzoyl; with dichloride of platinum, it
loroplatinate of ammonium.

th Acid Sulphite of Sodium. $C^7H^5NO^3.SO^3NaH + 5$Aq.—Obtained in the
nner manner as (*a*), in yellow scales, which are rendered nearly colourless by
llisation from a little hot water. It is readily soluble in hot, less so in cold
ffloresces in the air: loses its water at 70°—80° C.; above 90° it is decomposed
ff hydrogen, sulphurous anhydride, and hydride of nitrobenzoyl, sulphite of
remaining behind. Its aqueous solution is decomposed by boiling, especially
ion of acids or alkalis.

ride of Thiobenzoyl. Hydride of Sulphobenzoyl. Sulphide of Stilbene.
icramyl. $C^7H^6S = C^7H^5S.H$ (Laurent, Ann. Ch. Phys. [3] i. 292. Roch-
Ann. Ch. Pharm. xxxvii. 346. Cahours, Compt. rend. xxv. 357.)—When
bitter-almond oil (crude or pure), is dissolved in 8—10 vols. alcohol, and
lphide of ammonium gradually added, this compound speedily separates as
powder, which is easily purified by washing with alcohol. It is also obtained
alcoholic solution of hydrobrobenzamide is supersaturated with sulphuretted
, and the liquid left at rest. It is a white powder consisting of microscopic
; is inodorous, but imparts to the fingers a smell of onions; is insoluble in
alcohol. With ether it forms a transparent liquid, which resolidifies on adding
ops of alcohol. It becomes soft at 90°—95° C. After fusion it solidifies to a
ent non-crystalline mass. By dry distillation, it evolves sulphuretted hydrogen
lphide of carbon, and yields a sublimate of stilbene and thionessal:

$$8C^7H^6S = 2CS^2 + 3H^2S + \underset{\text{Stilbene.}}{2C^{14}H^{12}} + \underset{\text{Thionessal.}}{C^{26}H^{18}S.}$$

with an offensive smell and bright smoky flame. With *bromine*, it evolves
mic acid, and forms an oily body. Heated with *nitric acid*, it yields sulphuric
hydride or hydrate of benzoyl; with *sulphuric acid*, it dissolves, forming a
solution, which water decolorises, precipitating yellow flakes; boiled with

hydrochloric acid, it evolves a little sulphuretted hydrogen. It is slowly deco by *alcoholic potash;* water separates an oil from the solution, and acids sulphuretted hydrogen from the alkaline liquid. It is isomeric with sulp benzylene.

Hydride of Thionitrobenzoyl. Sulphide of Nitrobenzylene. C^7H^5 $C^7H^4(NO^2)S.H$ (Bertagnini, Ann. Ch. Pharm. lxxix. 269).—When an solution of hydride of nitrobenzoyl is saturated with sulphuretted hydrogen, t pound separates as a grey light mealy powder, which is inodorous, but impar agreeable smell to the fingers. It becomes electric when rubbed. It does not in the usual solvents, but melts in boiling *water*, aggregates together in boili *hol*, and becomes soft and transparent with *ether* in the cold. It dissolves i *sulphuric acid*, and is reprecipitated unaltered by water. Strong nitric acid poses it in the cold, dilute *nitric acid* on heating, forming sulphuric acid and h nitrobenzoyl. *Alcoholic potash* dissolves it in the cold, and water precip brown substance from the solution. *Ammonia*, whether dry or aqueous, a evolving sulphuretted hydrogen, and forming (probably) trinitrohydrobenzam

Oxyiodide of Benzaldide. $C^{21}H^{18}I^4O$ (Geuther and Cartmell, Pharm. cxii. 1).—This compound, which may be regarded as a triple mo hydride of benzoyl ($C^{21}H^{18}O^3$), having 2 at. O replaced by 4 at. I, is produce action of hydriodic acid gas on hydride of benzoyl. Two layers of liquid are formed, the upper consisting of aqueous hydriodic acid; the lower, which is oil oxyiodide: the latter may be purified by repeated treatment with water and phite of sodium. It is then obtained as a solid mass, which melts at 28 crystallises at 25° in colourless rhombic plates; smells like cress; dissolves r alcohol and ether, and is insoluble in water. It may be distilled with water decomposition; is not decomposed by acid sulphites of alkali-metals, but is res alcoholic potash into iodide of potassium, a small quantity of benzoic acid oily body soluble in alcohol, but different from bitter-almond oil. By amn appears to be gradually converted into hydride of benzoyl Boiled with silver, it forms iodide of silver, and emits an odour of bitter-almond oil.

BENZOYL, IODIDE OF. $C^7H^5O.I.$ (Liebig and Wöhler, A Pharm. iii. 266.)—Obtained readily by heating iodide of potassium with ch benzoyl; a brown liquid distils over, which solidifies to a crystalline mass, brown by free iodine. When pure, it is colourless, lamino-crystalline and fusible, always with partial decomposition; in solubility and general reactio sembles bromide of benzoyl. F.

BENZOYL, PERCHLORIDE OF. See Benyoyl, Chloride of.

BENZOYL, SULPHIDE OF. $(C^7H^5O)^2S$ (Liebig and Wohler, —When chloride of benzoyl is distilled with finely-powdered sulphide of yellow oil passes over, which solidifies to a soft yellow crystalline mass. It unpleasant sulphurous smell; is not decomposed by boiling with water or alc but slowly with aqueous potash; burns with a bright smoky flame, giving phurous anhydride. F.

BENZOYL SULPHOCYANIDE OF. See Sulphocyanobenzylene.

BENZOYLAZOTIDE. $C^{15}N^2H^{12}$ (Laurent (1837), Ann. Ch. Phys. 187. Laurent and Gerhardt, Compt. chim. (1850), 115. Robson, Chem. J. iv. 225).—A product of the action of ammonia on bitter-almond oil. residue insoluble in alcohol, obtained in the preparation of *azobenzoyl*, *benzhy* and *dibenzoylimide* (*q. v.*) It is a white powder, without taste or smell, con microscopic prisms. It is insoluble in water; requires 300—400 pts. boiling for its solution, and at least as much ether. Fuses when heated, and solidi vitreous mass, in which a few oblique prisms separate. When boiled with al hydrochloric acid, it is slowly decomposed, evolving hydrocyanic acid. By d lation, it yields an oil, then a sublimate of lophine and amarone, and carbonaceous residue.

Gerhardt (Traité, iii. 194) describes this body and benzhydramide name of *hydrides of cyanazobenzoyl.*

Quadrat (Ann. Ch. Pharm. lxxi. 18), by heating sulphocyanobenzylene, a resinous mass, which, when exhausted with alcohol, left a crystalline re soluble in water, almost so in alcohol, to which he assigns the formula The crystals are permanent at 100° C. and are not decomposed by nitric aci

BENZOYL-BENZOIN. See Benzoin.

BENZOYL-UREA. Syn. with Benzocarbamide. See Carbamide.

LUREID. $C^{25}H^{28}N^8O^4$ (Laurent and Gerhardt, Compt. chim.
).—Formed by the action of urea on hydride of benzoyl:

$$4CH^4N^2O + 3C^7H^6O = C^{25}H^{28}N^8O^4 + 3H^2O.$$

owdered urea are heated to somewhat below 100° C. with 2 pts. hydride of
nixture becomes liquid, and shortly solidifies to a compact mass. When
owdered, freed from excess of hydride of benzoyl by ether, and of urea by
ater; the residue, which is dried at 120°, is benzoylureid. It is a white
vder, without smell or taste, insoluble in water or ether, soluble in alcohol,
arates on evaporation in amorphous crusts. It turns yellow at 170° C.
ide of benzoyl a few degrees higher, and when further heated, yields
nzoyl and ammoniacal water, leaving a yellow residue, which finally
npletely, and is sparingly soluble in alcohol. When boiled with dilute
composed into hydride of benzoyl and urea. It is not decomposed by
nia; slowly by strong boiling potash, evolving ammonia and hydride of
eaving potassic benzoate in solution. Hydride of nitrobenzoyl yields
nilar compound. (Bertagnini.) F. T. C.

EID, Syn. with BENZOYL-UREA. See CARBAMIDE.

Tolyl. Toluenyl. C^7H^7.—A hypothetical radicle, isomeric with cresyl,
enzylic alcohol, toluene, and other compounds. F. T. C.

CHLORIDE OF. *Chloride of Tolyl* or *Toluenyl. Chlorotoluol.*
nizzaro, Ann. Ch. Pharm. lxvxviii. 129; xcvii. 246. Deville, Ann.
iii. 178).—Obtained by saturating benzylic alcohol with hydrochloric
upon heat is evolved, and the liquid divides itself into two layers, the lower
eous hydrochloric acid, the upper chloride of benzyl. Or by passing chlo-
ide of benzyl in the dark, expelling excess of chlorine by a stream of
dride, and rectifying the product. It forms a colourless liquid, of specific
at 0° C; boils at 170° (Deville); 175°—176° (Cannizzaro); insoluble
ble in alcohol or ether. It is not attacked by aqueous potash; alcoholic
poses it on boiling into benzylethylic ether and chloride of potassium.
with an alcoholic solution of acetate of potassium, it is converted into
nzyl; of cyanide of potassium, into cyanide of benzyl. When heated
be with alcoholic ammonia, it yields tribenzylamine. F. T. C.

CYANIDE OF. *Cyanide of Tolyl* or *Toluenyl.* $C^8H^7N = C^7H^7.CN.$
, Ann. Ch. Phys. [3] xlv. 468).—Obtained by boiling chloride of benzyl
alcoholic solution of cyanide of potassium, till no more chloride of
arates out, and distilling the filtrate to remove the alcohol. The residual
es into two layers, the upper containing cyanide of benzyl, which may be
it by rectification. It is a colourless liquid, which, by boiling with strong
verted into toluic acid, $C^8H^8O^2$. F. T. C.

HYDRATE OF. Syn. with BENZYLIC ALCOHOL (*q. v.*)

HYDRIDE OF. *Hydride of Tolyl* or *Toluenyl. Toluene* or *Toluol.*
racyl. $C^7H^8 = C^7H^7.H.$—Discovered by Pelletier and Walter (1837) in
cts obtained in the manufacture of illuminating gas from resin; first
Deville.

By the action of potash on benzylic alcohol (Cannizzaro, Ann. Ch.
2; xcvi. 246):

$$3C^7H^8O + KHO = C^7H^5KO^2 + 2C^7H^8 + 2H^2O.$$

toluic acid with excess of lime (Noad, *ibid.* lxiii. 305):

$$C^8H^8O^2 = C^7H^8 + CO^2.$$

distillation of tolu-balsam (Deville, Ann. Ch. Phys. [3] iii. 152, 168;
nd Hofmann, Ann. Ch. Pharm. liv. 9); of dragon's blood (Glénard
t, Ann. Ch. Phys. [3] iv. 274); of the resin of *Pinus maritima* (Pelle-
alter, *ibid.* [2] lxvii. 269); of Burmese naphtha (De la Rue and
. Roy. Soc. viii. 221); of resin-oil (Couerbe, Ann. Ch. Phys. [2] lxix.
d (Völckel, Ann. Ch. Pharm. lxxxvi. 334), and of coal. In distilling
ortion which passes over at 100°—115° C. consists of toluene (Mansfield,
n. J. i. 266).—4. The yellow oil which separates from crude wood-spirit
water contains hydride of benzyl. (Cahours, Compt. rend. xxx. 319.)
.—1. When benzylic alcohol is distilled with four or five times its volume
oholic potash in an apparatus which allows the less volatile products to
n, alcohol first passes over, then water, and finally, when the residue has
a mixture of hydride and hydrate of benzyl. This mixture is distilled
portion which passes over at 116° C. collected apart and shaken up with

sulphuric acid, the decanted liquid washed with potassic carbonate, and twice
over phosphoric anhydride.—2. When tolu-balsam, freed by distillation w
from toluene, cinnamein, and a portion of the benzoic acid is subjected to dr
tion, there passes over,—besides carbonic oxide and anhydride,—water, abu
benzoic, and a little cinnamic acid, a heavy oil consisting of a mixture of benzoa
(benzoate of methyl, according to Muspratt and Scharling), and hydride
This oil is distilled, and the portion which passes over at 13°—140° C. repea
tified over strong aqueous potash, and dried over chloride of calcium.
(Compt. chim. 1849, p. 149) purifies the balsam by boiling with sodic carbo
the residue with strong aqueous soda, distils the brown solution, decants the
passes over from the water which accompanies it, and rectifies it repeatedl
prepare hydride of benzyl from coal-tar, the oil which comes over at 100°—
mixed with half its weight of sulphuric acid and rectified, when a product o
boiling-point is obtained. (Wilson, Chem. Soc. Qu. J. iii. 154.)

Hydride of benzyl is a colourless, very mobile, strongly refracting liqu
smell like benzene, and a burning taste; specific gravity 0·87 at 18° C. (
The boiling-point is variously stated at from 103°·7 (Church), to 114° (G
vapour-density 3·27 (Deville); does not solidify at −20°. It is insoluble
slightly soluble in alcohol, more so in ether or in fixed or volatile oils. I
most resins, also iodine, forming an amber-red solution, and, when heat
which crystallises out on cooling.

It is not decomposed when passed through a red-hot tube filled with po
It burns with a smoky flame. With *chlorine*, it evolves heat, and yields se
stitution-compounds (see below). With fuming *nitric acid*, it yields substit
pounds (see below). It dissolves in fuming *sulphuric acid*, forming sulp
(sulphotoluic) acid, and sulphibenzyl (sulphotoluol). It is not attacked
potassium or by *potash*. When digested with *sodium*, in a closed vessel fo
days, it yields two substances, boiling respectively at 97° C. and 112°.
Phil. Mag. [4] ix. 256.)

Substitution-products of Hydride of Benzyl.

Deville (Ann. Ch. Phys. [3] iii. 178) enumerates several compounds ob
the action of chlorine on hydride of benzyl. When the reaction takes p
dark, *chloride of benzyl* (chlorotoluol) is the product (see Benzyl, Ch
When chlorine is passed through hydride of benzil in bright daylight, as l
drochloric acid is evolved, and excess of chlorine removed by carbonic
hydrochlorate of trichlorotoluol, $C^7H^4Cl^6 = C^7H^5Cl^3.HCl$, is formed; when
decomposes and evolves hydrochloric acid. When the action of the gas is s
prolonged, a thickish liquid is formed, together with some crystals. If the liqu
rated, further treated with chlorine with aid of heat, and purified by carb
dride, the product is *dihydrochlorate of pentachlorotoluol*, $C^7H^5Cl^7$ = C^7H^3
when distilled it evolves hydrochloric acid; it is soluble in ether. The cryst
hydrochlorate of pentachlorotoluol, $C^7H^6Cl^8 = C^7H^3Cl^5.3HCl$, they are purified
tallisation from ether, in which they are soluble, especially with aid of heat
colourless when pure. When the liquid and crystals together are distilled i
of chlorine, the distillate being repeatedly poured back again, the whole is
converted into a silky substance, abundance of hydrochloric acid being evo
substance, which is *hexchlorotoluol* (hydride of hexchlorobenzyl), $C^7H^2Cl^6$,
by pressure between filter-paper and recrystallisation from ether; it is volati
decomposition.

Hydride of Nitrobenzyl. Nitrotoluol. $C^7H^7NO^2 = C^7H^6NO^2.H$. (De
cit.; Glénard and Boudault, Compt. rend. xix. 505; Hofmann and M
Ann. Ch. Pharm. liii. 220, 224.)—Hydride of benzyl is added to cold fuming
as long as it dissolves immediately; on adding water to the red solution, h
nitrobenzyl separates as a red liquid, which may be decolorised by was
water and repeated distillation. It is a nearly colourless liquid, smelling
almonds, with a very sweet and afterwards pungent taste; specific gravi
16°·5 C.; vapour-density 4·95; boils at 225°—230° C. Readily soluble in
ether. It is partially decomposed by distillation, completely when passed at a
perature through a red-hot tube filled with pieces of glass. It burns with
flame, emitting the odour of gum-benzoin; when passed over red-hot baryt
solved into phenylamine and carbonic anhydride. With fuming sulphuric aci
nitrosulphotoluic acid (Church). Aqueous potash dissolves it, forming a re
whence hydrochloric acid precipitates a brown powder; with alcoholic potas
a black liquid, whence a reddish oil containing phenylamine is obtained by di
Boiled with alcoholic sulphite of ammonium, it forms thiotoluate of a
With sulphide of ammonium, it yields benzylamine.

Dinitrobenzyl. Dinitrotoluol. $C^7H^6N^2O^4 = C^7H^5(NO^2).{}^2H$. (**De-**
Cahours, Compt. rend. xxiv. 555.)—Obtained by boiling hydride of
ing nitric acid, or treating it with nitrosulphuric acid. It crystallises
lustrous, hard, brittle, prismatic needles, which melt at 71° C. and
diated mass. It boils at 300°, becoming coloured, and leaving a resi-
ngly heated, it yields a sublimate. It is sparingly soluble in water.
ed by fuming nitric acid. Its solution in potash deposits a brown
ition of hydrochloric acid. Sulphide of ammonium converts it into
e. F. T. C.

ODIDE OF. C^7H^7I. (**Cannizzaro**, 1854.)—When a solution of
in bisulphide of carbon is mixed with a solution of phosphorus in bi-
bon, iodine gradually added, and excess of bisulphide distilled off,
ned, which irritates the eyes, and is probably iodide of benzyl.
F. T. C.

MINE. *Toluidine.** $C^7H^9N = N.C^7H^7.H^2$. (**Muspratt** and **Hof-**
Ann. Ch. Pharm. liv. 1; **Noad**, *ibid.* lxiii. 305; **Hofmann**, *ibid.* lxvi.
Chem. Soc. Qu. J. iii. 154; **Chautard**, J. Pharm. [3] xxiv. 166.)—
e reduction of hydride of nitrobenzyl by sulphydric acid (**Mus-**
fmann): or by the action of potash on the yellow resin obtained by
urpentine by nitric acid. (**Chautard.**)

—1. A solution of hydride of nitrobenzyl in alcohol saturated with
ated with sulphuretted hydrogen till it smells strongly of the gas, even
ing: sulphur then crystallises out. The reaction is accelerated by the
eat, but the decomposition is never complete. The product is mixed
hydrochloric acid, and shaken up with ether to remove undecomposed
hen evaporated to ½, and distilled with potash, when water, ammonia,
ne pass over, the last as a heavy oil, which soon crystallises. The
is saturated with oxalic acid, evaporated to dryness on the water-bath,
vith boiling absolute alcohol, which dissolves only the oxalate of benzyl-
rystallises on cooling. The crystals are washed, dissolved in boiling
solution decomposed by strong potash, when benzylamine separates in
h collect and crystallise into a radiated mass on cooling: it is purified
l one rectification, or by crystallisation from ether.—2. The resin ob-
ng oil of turpentine with nitric acid, is gradually mixed with aqueous
xture assumes a dark-brown colour, and becomes hot, and when the
ased, it is distilled as long as alkaline vapours pass over. The dis-
aturated with hydrochloric acid, evaporated to dryness over the water-
usted with absolute alcohol, which dissolves hydrochlorate of benzyl-
es sal-ammoniac undissolved.

crystallises from dilute alcohol in large colourless laminæ, which are
le in cold, more readily in boiling, water: readily in alcohol, ether,
tone, fixed and volatile oils, and bisulphide of carbon. It smells like
nd has a burning taste. It evaporates at ordinary temperatures, melts
olourless, strongly-refracting oil, and boils at 198°. It is heavier than
blues red litmus, but does not redden turmeric; colours fir-wood deep
s not give the purple colour of phenylamine with chloride of lime, but
ddish tint. With nitric acid benzylamine gives a deep-red, phenyla-
ne, colour.

on benzylamine violently: when the product is heated, shining needles
ble in water, soluble in alcohol and ether,—probably *tribromobenzyla-*
composed by boiling with strong *nitric acid*, with evolution of nitrous
added to the solution precipitates yellow flakes, which dissolve in
e reprecipitated by acids. With aqueous *chromic acid*, it gives a red-
te. When its vapour is passed over fused *potassium*, vivid combus-
e, and potassic cyanide is formed. *Cyanogen* passed into its alcoholic
cyanobenzylamine (see below).—With *chloride of cyanogen* it
nzylamine (metoluidine) (see below.) With *bromide* or *iodide of*
benzylethylamine (see below).

. 1. With Acids.—Benzylamine combines with acids, forming crys-
hich are mostly inodorous and colourless, but quickly become rose-
xposed to the air: they are decomposed by alkalis or alkaline carbonates,
eing separated as a crystalline curd. The *chloraurate*, $AuCl^4C^7H^{10}N$,
hick precipitate, which soon aggregates to a crystalline mass, when the
s mixed with trichloride of gold: it melts in water at 50°—60°C., dis-
her heated, and crystallises on cooling in fine yellow needles. The *chloro-*
$H^9N.HCl).PtCl^4$, separates as an orange-yellow crystalline pulp, when the

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formed by heating benzyl chloride with alcoholic ammonia is isomeric, not iden-
e, the compound described in this article (see v. 867, and Supplement, p. 337).

hydrochlorate is mixed with bichloride of platinum: it is washed with ethe
and dried in a water-bath. The *chloropalladate* is similar in appearance. Th
chlorate, $C^7H^{10}NCl$, is deposited in white crystalline scales, becoming ye
exposure to the air, when a solution of benzylamine in hydrochloric acid is ev
and cooled: it is readily soluble in water or alcohol, sparingly in ether, form
solutions: when gently heated, it sublimes like sal-ammoniac. The *nitrate*, *p*
and *sulphite* are crystallisable. The *acid oxalate*, $C^2O^4.C^7H^{10}N.H + \frac{1}{2}Aq$, is
by mixing an alcoholic solution of benzylamine with excess of oxalic acid, in
silky needles, soluble in boiling water or alcohol, insoluble in ether. The
$SO^4(C^7H^{10}N)^2$, is obtained when a few drops of sulphuric acid are added to an
solution of benzylamine, as a white crystalline precipitate, which may be was
ether: it is readily soluble in water, sparingly in alcohol. With *cupric su*
chloride, benzylamine gives a greenish crystalline precipitate; with *nitrate*
a white precipitate, which soon blackens; it precipitates ferric hydrate fro
chloride.

2. With Cyanogen; *Cyanobenzylamine; Cyanotoluidine.* $C^8H^9N^2 = C$
(Hofmann, *loc. cit.* Chem. Soc. Qu. J. i. 170.)—When cyanogen is passed thr
alcoholic solution of benzylamine, the red-brown solution deposits, after some
crystalline mass, whence hydrochloric acid extracts cyanobenzylamine, whic
cipitated by potash from the hydrochloric acid solution. It is homologo
cyanophenylamine, which it closely resembles, only being less soluble in a
ether.

Melobenzylamine. Metoluidine. $C^{15}H^{17}N^3 = C^7H^9N.C^7H^8CyN$. (Wil
cit.)—When the vapour of chloride of cyanogen is passed over fused benz
heat is evolved, and a resinous mass obtained, consisting of hydrochlorate of
dine; this is dissolved in water acidulated with hydrochloric acid, filtered, ar
with potash; and the white precipitate thus produced, is boiled with potash, was
recrystallised from alcohol. Crystalline laminæ, sparingly soluble in cold, s
more in boiling water; crystallises best from a mixture of water and alcohol
soluble in hydrochloric acid: the solution gives with dichloride of platinum,
yellow precipitate of *chloroplatinate*, which is insoluble in water or alcohol
be dried at 100° C. It is homologous with melaniline (melophenylamine).

Secondary and Tertiary Amines containing Benzyl.

Benzylethylamine. Ethyltoluidine. $C^9H^{13}N = N.C^7H^7.C^2H^5.H$. (Mor
Abel, Chem. Soc. Qu. J. vii. 68.)—Benzylamine is heated with iodide of ethyl in
tube for two or three days in a water-bath; the product freed from excess of i
heat; the resulting oil, which is hydriodate of benzylethylamine, distilled wit
potash, and the distillate rectified over solid potash. It is a colourless oil with a
smell: specific gravity 0·9391 at 15°·5 C.; boils at 217° The *chloroplatinate* i
yellow crystalline compound, soluble in water or alcohol, less so in ether: a
becomes dark, and is decomposed. The *oxalate* and *sulphate* are crystalline.

Benzyldiethylamine. Diethyltoluidine. $C^{11}H^{17}N = N.C^7H^7.(C^2H^5)^2$.—
in the same manner as the foregoing compound, benzylethylamine being substi
benzylamine. A colourless, odorous oil: specific gravity 0·9242 at 15·5 C., boils
The *chloroplatinate* is a resinous non-crystalline mass. The *hydriodate* forms o
which crystallise when touched with a glass-rod; is very soluble in water, de
when exposed to the air, or in contact with alcohol.

Benzyltriethylium. $C^{13}H^{22}N = N.C^7H^7.(C^2H^5)^3$.—Known only in com
with acids. When benzyldiethylamine is heated with iodide of ethyl to 100°
sealed tube till crystals are formed and excess of iodide of ethyl is removed
tillation, *iodide of benzyltriethylium* remains as a heavy oil. This is dec
by heating with oxide of silver, yielding a solution of *hydrate of benzyltri*
$N.C^7H^7(C^2H^5)^3.H.O$, which is strongly alkaline, has a bitter taste, and pre
most metallic salts. The *chloroplatinate* is insoluble in cold, soluble in ho
whence it crystallises in fine needles; it loses platinum on recrystallisation.

Nitrobenzylamine. Nitrotoluidine. $C^7H^8N^2O^2 = N.C^7H^6NO^2.H^2$. (C
Compt. rend. xxx. 320.)—Formed by the action of sulphide of ammonium on
of dinitrobenzene; it crystallises in yellow needles, forms definite compoun
nitric, hydrochloric, sulphuric, and phosphoric acids: yields alkalamides
chlorides of benzene and cumyl.

Tribenzylamine. $C^{21}H^{21}N = N.(C^7H^7)^3$. (Cannizzaro, Cimento, iii.
When chloride of benzyl is heated with alcoholic ammonia to 100° C. in a seal
ammonia passed into the cooled product, the resulting precipitate exhaust
ether, and the ethereal solution evaporated, this compound is obtained in
laminæ, which melt at 91·3° C. to a colourless liquid, and at 360° volati

composition. It is sparingly soluble in cold water or alcohol, more so in boil-
ol. still more in ether, forming alkaline solutions. The *hydrochlorate* crystal-
edles from hot water. The *chloroplatinate* forms orange-needles. F. T. C.

YLENE. C^7H^6.—A hypothetical diatomic radicle, of which, according to
Ann. Ch. Pharm. cii. 356.) Cahours' chlorobenzol is the chloride. It has
solated; neither has its hydrate (benzylenic or benzolic alcohol,) $C^7H^6.H^2.O^2$,
xide (benzylenic ether) C^7H^6O been obtained; the reason assigned by Wicke
t the former readily decomposes, yielding water and the latter compound,
turn is readily converted into its isomer, hydride of benzoyl. Several com-
ners have, however, been obtained, representing the alcohol in which the
of basic hydrogen are replaced by positive or negative organic radicles (see
NIC ETHERS). Hydrobenzamide $C^{21}H^{18}N^2$, should probably be regarded as a
iamine containing this radicle. $N^2(C^7H^6)^3$. F. T. C.

YLENE, CHLORIDE OF. *Chlorobenzol.* $C^7H^6Cl^2$. (Cahours (1848),
Phys. [3] xxiii. 129. Wicke, Ann. Ch. Pharm. cii. 356.)—When hydride of
brought into contact with a slight excess of pentachloride of phosphorus, a
on takes place; and if, when this is over, a gentle heat be applied, oxychloride
horus distils over at about 110° C., and chloride of benzylene at about 206°.
r is washed with water, dried over chloride of calcium, and rectified. It is a
liquid, smelling faintly in the cold, but strongly when heated; insoluble in
luble in alcohol or ether: specific gravity 1·245 at 16°: vapour-density
595; boils at 206°—208°. It is not oxidised by exposure to the air, or to
When heated in a water-bath with alcoholic *potash*, more slowly with
otash to 100°, in a sealed tube, it yields chloride of potassium and hydride
l. *Ammonia*, whether dry, aqueous, or alcoholic, does not act upon it in the
en heated in a sealed tube to 100° with an ammonia-solution, it yields
f ammonium, and bitter-almond oil. It is not attacked by dry *cyanide of*
at 100°. Heated with alcoholic *sulphocyanate of potassium* to 100° in a
be, it yields chloride of potassium, and an oil smelling like oil of mustard.
nitrate of silver deprives it of all its chlorine, hydride of benzoyl being formed.
hydrosulphate of potassium converts it into sulphide of benzylene.
rdt (Traité, iii. 167) regards this compound as hydride of benzoyl in which
replaced by chlorine: Wicke, however, shows conclusively that it possesses
he properties of an aldehyde. F. T. C.

YLENE, SULPHIDE OF. *Sulphobenzol*, C^7H^6S. (Cahours, *loc. cit.*)
d by the action of alcoholic sulphydrate of potassium on chloride of benzylene,
stallised from boiling alcohol, in which it is readily soluble. White pearly
soluble in water, which melt at 64° C. and crystallise on cooling: when further
is partly volatilised, and partly decomposed. It is oxidised even by dilute
d, with formation of sulphuric acid, and a substance soluble in alkalis, which
es in shining yellow scales. F. T. C.

YLENE-PHENYLAMINE. *Benzosylanilide. Stilbylaniline.* $C^{13}H^{11}N =$
H^6. (Laurent and Gerhardt, Compt. chim. 1850, 117.)—When perfectly
ide of benzoyl is mixed with about its own volume of perfectly dry phenyl-
ater separates out, and a crystalline mass forms after a time (sometimes not
er is added): this is pressed between filter-paper, and recrystallised from hot
r purified by rectification. It forms beautiful shining laminæ, without taste
insoluble in water, soluble in alcohol or ether. It is easily fusible, and boils
high temperature without decomposition. *Bromine* acts with violence on its
solution, forming after a time crystals of tribromophenylamine. With cold
itric acid, it forms a dark-green solution, whence water precipitates hydride
yl, nitrate of phenylamine remaining in solution: *sulphuric acid* decomposes
milar manner, forming a yellow solution. It becomes liquid by contact with
ydrochloric acid: the latter dissolves it on boiling, without decomposition.
cely attacked by boiling potash. F. T. C.

YLENIC ETHERS. Salts or ethers of Benzylene. (Wicke, *loc. cit.*)

a. *Ethers containing a Positive Radicle.*

LBENZYLENIC ETHER. *Methylate of Benzylene.* $C^9H^{12}O^2 = C^7H^6.(CH^3)^2O^2$.
ture of 1 at. chloride of benzylene with a solution of 2 at. sodium in abso-
ylic alcohol, is heated for some hours, when chloride of sodium separates in
e; the methylic alcohol is distilled off, and the residue mixed with water,
ether rises to the surface, and is removed with a pipette, dried and rectified.
ansparent, colourless liquid, heavier than water, with a pleasant smell like
eraniums; insoluble in water, soluble in wood-spirit, alcohol, or ether. It
08° C., leaving a brown residue arising from decomposition.

ETHYLBENZYLENIC ETHER. *Ethylate of Benzylene.* $C^{11}H^{16}O^2 = C^7H^6(C^2H$ Prepared precisely like the foregoing compound, ethylic being substituted for m alcohol. It boils at 222° C.: in other respects it resembles the methyl-compo

AMYLBENZYLENIC ETHER. *Amylate of Benzylene.* $C^{17}H^{28}O^2 = C^7H^6.(C^5H$ Prepared like the preceding compounds: but the ether must be separated by f distillation, not by addition of water. It is a slightly yellowish oil, smelling li oil, and lighter than water: it boils, not without considerable decompositio 292° C.

b. *Ethers containing Acid Radicles:*

The only one of these which has been obtained perfectly pure, and in the c form, is

ACETOBENZYLENIC ETHER. *Acetate of Benzylene.* $C^{11}H^{12}O^4 = C^7H^6.(C^2H$ 1 at. chloride of benzylene is triturated with rather more than 2 at. dry a silver, and the mixture heated very gently in a flask; the reaction is so vio it is well not to use more than 10 grm. silver-salt at a time. The product, w is repeatedly extracted with ether; the extracts are distilled in the water-b the yellowish oily residue is washed with weak soda-solution and with wa redissolved in ether, and left to evaporate. A viscid oil is thus obtained, crystals gradually form, until at last it solidifies completely. It forms small whit crystals, belonging to the monoclinic system, insoluble in water, soluble in a ether, whence it separates on evaporation as an oil, which often does not cryst agitated. It melts at 36° C., and crystallises on cooling: begins to boil at temperature gradually rising to 240°, and yields a distillate consisting of a hydride and hydride of benzoyl. Heated with aqueous potash or dilute acid, to 100° in a sealed tube, it is converted into acetic acid and hydride of with aqueous ammonia under the same circumstances, it yields acetamide an benzamide.

BENZOBENZYLENIC ETHER. *Benzoate of Benzylene.* $C^{21}H^{16}O^4 = C^7H^6.(C^7H$ Chloride of benzylene acts violently on benzoate of silver, with evolution of ethereal extract of the product yields on evaporation a viscid, brown, non-crys mass. With alcoholic potash it forms immediately a solid mass of potassic mixed with hydride of benzoyl.

SUCCINOBENZYLENIC ETHER. *Succinate of Benzylene.* $C^{11}H^{10}O^4 = C^7H^6.C$ —Prepared like the foregoing compounds: its ethereal solution is decom evaporation or by washing with dilute soda, into succinic acid and hydride o

SULPHOBENZYLENIC ETHER. *Sulphate of Benzylene.* $C^7H^6SO^4 = C^7H^6SO^2.$ pared in the same manner. It is a red-brown, non-crystallisable oil.

VALEROBENZYLENIC ETHER. *Valerate of Benzylene.* $C^{17}H^{24}O^4 = C^7H^6.(C^5$ —Obtained like the acetate. On evaporating its ethereal solution, it remains a yellow, non-crystallisable oil, which is decomposed by distillation into valer and hydride of benzoyl.

Chloride of benzylene acts so violently on oxalate of silver, that no definit can be obtained. F

BENZYLETHYLAMINE. BENZYLDIETHYLAMINE. B TRIETHYLIUM. (See BENZYLAMINE.)

BENZYLIC ALCOHOL. *Hydrate of Benzyl. Benzoic Alcohol. Alcohol.* $C^7H^8O = C^7H^7.H.O.$ (Cannizzaro [1853], Ann. Ch. Pharm. lxxxviii 252; xcii. 113; xcvi. 246; Scharling, *ibid.* xcvii. 168.)—Formed: 1. By of alcoholic potash on hydride of benzoyl:

$$2C^7H^6O + KHO = C^7H^8O + C^7H^5KO^2.$$

When a mixture of pure hydride of benzoyl with its own volume of absolute mixed with 3—4 vols. alcoholic potash, of specific gravity 1·02, heat is evolve whole solidifies to a crystalline magma. The potassic benzoate is dissolved hot water, the alcohol distilled off, the residue mixed with water till it be turbid, and then shaken up with ether. The brown oily residue obtaine porating the ethereal solution, is dried over fused potash, and repeatedly r 2. When acetate of benzyl, obtained by boiling chloride of benzyl with alco tate of potassium, is boiled with strong alcoholic potash, and the alcohol di the residual liquid separates into two layers, the upper of which contain alcohol, which is separated by fractional distillation.—3. Scharling has s the substance known as *peruvin*, obtained by the action of potash on cin benzylic alcohol.

It is a colourless, strongly-refracting oil, with a faint pleasant smell: spec 1·051 at 14°·4 C., 1·063 at 0° (Kopp): vapour-density (expt.) 3·85: boils

ure of 751·4 mm. (Kopp). It is insoluble in water: soluble in all pro-
alcohol, ether, acetic acid, or bisulphide of carbon.
vapour is passed through a red-hot tube filled with spongy platinum, ben-
ther compounds is formed. It is converted into hydride of benzoyl by
resence of platinum-black, or by *nitric acid:* aqueous *chromic acid* converts
ic acid. With strong *sulphuric acid, phosphoric anhydride,* or *chloride of*
ds a brown resin, insoluble in water, alcohol, or ether (probably stilbene).
anhydride converts it at 100°—120° C. into benzylic ether, at a higher
into stilbene (or benzylene?): with *fluoride of boron,* it yields the same
istilled with strong alcoholic potash, it yields hydride of benzyl (*q. v.*)

F. T. C.

LIC ETHER. $C^{14}H^{14}O = (C^7H^7)^2.O$. (Cannizzaro, Ann. Ch. Pharm.
Fused and pulverised boric anhydride is mixed into a paste with benzylic
mixture is heated for some hours to 120°—125° C.; and the resulting hard
is treated with water and a solution of alkaline carbonate, when a greenish-
es to the surface. When this is distilled, benzylic alcohol passes over below
nzylic ether at 300°—315°: the residue contains stilbene. Benzylic ether
s, slightly fluorescent oil, boiling at 300°—315°. When heated above its
, it becomes yellow and is decomposed, yielding resinous stilbene, hydride
and a light oil, which is probably hydride of benzyl. With phosphoric
r sulphuric acid, it yields the same product as benzylic alcohol.

nzylic Ether. $C^9H^{12}O = C^7H^7.C^2H^5.O$. (Cannizzaro, Cimento, iii. 397.)
f benzyl is distilled upwards with alcoholic potash, and the resulting liquid is
m the chloride of potassium, and mixed with water, when it separates into
the upper of these is distilled, and the portion which comes over at 185° C.
hloride of calcium and rectified. Colourless, mobile liquid, with a pleasant
er than, and insoluble in, water: boils at 185°.

ompound benzylic ethers containing acid radicles, see ACETIC and BENZOIC

F. T. C.

ITE. A hydrated sesquiphosphate of iron occurring at St. Benigna in the
raun in Bohemia, together with cacoxene and Dufrenite. It forms ra-
ninar masses, with perfect cleavage in one direction; imperfect at right
first. Specific gravity 2·878. Hardness 2·0 to 2·5. Rather brittle.

RINE. $C^{20}H^{17}NO^4$. An organic base discovered in 1837, by Buchner
harm. xxiv. 228), in the root of the barberry (*Berberis vulgaris*), and
in other species of Berberis growing in Mexico and in India. It has also
d by Bödeker (Ann. Ch. Pharm. lxvi. 384; lxix. 40), from colombo-
us palmatus); by Perrins (Chem. Soc. J. xv. 339), from the colombo-
on and several other sources (*Menispermum fenestratum*); and by Sten-
rm. J. Trans. xiv. 455), from a yellow bark used as a dye by the natives of
West Africa. (See APPENDIX v. 1088, and SUPPLEMENT, p. 339.)

on. *a. From Barberry-root.*—The root is exhausted with boiling water;
concentrated by evaporation, and treated with warm alcohol of 82 per
olution filtered; the greater part of the alcohol distilled off; and the
to itself in a cool place. Yellow crystals of berberine are then deposited,
purified by recrystallisation from boiling water or alcohol. The root con-
1·3 per cent. of berberine. (Buchner.)

Colombo-root. — The dried alcoholic extract of the root is treated with hot
filtered solution neutralised with hydrochloric acid; and the liquid again
ted with excess of hydrochloric acid, and left at rest for some days. It
s a crystalline sediment of hydrochlorate of berberine, which is dissolved
uantity of alcohol and reprecipitated by ether (Bödeker). For further
the hydrochlorate is converted into a sulphate; this salt is recrystallised
100° C.; the aqueous solution decomposed by baryta-water; the excess of
ved by passing a stream of carbonic acid through the liquid, then filtering,
nearly to dryness, and digesting the residue in alcohol. The alcoholic
then precipitated by ether, and the precipitated berberine recrystallised
The same mode of purification may be adopted with berberine obtained
ry-root. (Fleitmann, Ann. Ch. Pharm. xxiv. 228.)

s.—Small silky needles or concentrically grouped prisms of a light yellow
ourless, but has a strong and persistently bitter taste. Sparingly soluble
l alcohol when cold; easily at the boiling heat; insoluble in ether. Oils,
nd volatile, dissolve it in small quantity.

to Fleitmann the crystals heated to 100° C. give off 19·26 per cent. (5 at.)
stallisation, and the residue contains 66·7 to 67·4 carbon, and 5·6 to 5·7
greeing nearly with the formula $C^{21}H^{19}NO^5.\frac{1}{2}H^2O$, or $C^{42}H^{19}NO^{10}HO$.

The remaining water cannot be expelled without further decomposition. F
supposes that the anhydrous salts of berberine contain the group $C^{42}H^{18}N$
ciated with acids: *e.g.* the hydrochlorate = $C^{42}H^{18}NO^{9}.HCl$. This for
however, by no means probable. Gerhardt suggested $C^{21}H^{19}NO^{5}$, but Pe
the analysis of several salts of berberine, has shown that the true formula of
is $C^{20}H^{17}NO^{4}$.

Berberine melts at 120° C. to a resinous mass, without loss of weight. Betw
and 200° C. it gives off yellow odorous vapours, which condense into a solid
soluble in water, but very soluble in alcohol, and leaves an abundant residue of
Ammonia colours berberine yellow-brown, and dissolves it in nearly the sam
tions as water. Berberine boiled with caustic potash-ley melts, and is conve
a resinous substance, sparingly soluble in water, easily in alcohol. Acc
Bödeker, berberine distilled with milk of lime or hydrate of lea
chinoline.

The *salts of berberine* are, for the most part, sparingly soluble in water;
them may be prepared by treating the hydrochlorate with a salt of potassium
chlorate of berberine, $C^{20}H^{17}NO^{4}.HCl + \frac{1}{2}H^{2}O$, crystallises in slender yellow
With sulphide of ammonium containing excess of sulphur, it forms a fœtid b
precipitate containing sulphur. The *chloroplatinate of berberine*, $2(C^{20}H^{17}NO^{4}.H$
is a yellow precipitate nearly insoluble in water; it gives by analysis 44·23
bon, 3·41 hydrogen, 2·80 nitrogen, and 18·21 platinum, the formula requiring
3·33 H., 2·59 N., and 18·21 Pt. The *chloroaurate*, $C^{20}H^{17}NO^{4}.HCl.AuC$
maroon-coloured needles soluble in alcohol. The *hydrobromate*, $C^{20}H^{17}NO$
$3H^{2}O$, and the *hydriodate*, $C^{20}H^{17}NO^{4}.HI$, form yellow needles. The
$C^{20}H^{17}NO^{4}.HClO^{3}$, is a bulky yellow precipitate obtained by mixing the hydr
with chlorate of potassium. It is moderately soluble in pure water,
soluble in saline liquids. The acid *chromate*, $2(C^{20}H^{17}NO^{4}.CrO^{3}).H^{2}O$, is
yellow precipitate, sparingly soluble in water, obtained by mixing the hydr
with acid chromate of potassium. It is very soluble in hydrochloric and
acids. When strongly heated, it decomposes suddenly, yielding a large qu
the yellow substance produced in the dry distillation of berberine. *Nitrate of*
forms yellow crystals sparingly soluble in cold water. The *acid*
$C^{20}H^{17}NO^{4}.SO^{4}H^{2}$, is deposited after a while in small yellow crystals o
sulphuric acid to a dilute solution of the hydrochlorate.

BERENGELITE. *Berengela resin.*—A bituminous mineral found in the
of St. Juan de Berengela in Peru, about one hundred miles from Arica, where
in amorphous masses of considerable extent, forming a sort of pitch-lake, lil
Trinidad (p. 426). It has a conchoïdal fracture, a dark brown colour, inc
green, and waxy lustre; yields a yellow powder; has a resinous unpleasant o
a rather bitter taste. Melts below 100° C., and after cooling remains soft and
at ordinary temperatures. It dissolves readily in cold alcohol and in ether.
for caulking ships. According to Johnston's analysis (Phil. Mag. [3] xiv
formula is $C^{20}H^{30}O^{4}$.

BERESITE is a fine-grained granite containing pyrites, occurring at Ber
the Ural, in the rocks in which the gold veins are found.

BERGAMOT, OIL OF. A volatile oil obtained by pressing the rind of
of orange, *Citrus bergamia*, cultivated in the south of Europe. The oil thus
is light-yellow or sometimes greenish or brownish-yellow; mobile, with a very
odour and aromatic somewhat bitter taste. Specific gravity 0·869. It
exhibits an acid reaction, arising from the presence of a small quantity of ac
It solidifies a little below 0° C., and at ordinary temperatures deposits, after
a solid camphor or stearoptene.

Bergamot-oil is a mixture of two essential oils, the more volatile of which is
with oil of turpentine and oil of lemon, $C^{10}H^{16}$; but it is difficult to separate
by simple distillation.

The less volatile portion which, when rectified, boils at 183° C. and has
of 0·856, contains oxygen, and according to Ohme (Ann. Ch. Pharm. xx
has the composition of a hydrate of oil of lemon, $3C^{10}H^{16}.2H^{2}O$. Acc
Soubeiran and Capitaine (J. Pharm. xxvi. 68, 509), this portion of the
of constant composition, but yields by fractional distillation, oils continually
ing in amount of oxygen, from 3·37 to 16·14 per cent. (perhaps the oil was
during the distillation). They find also that the first portions turn the
polarisation of a luminous ray to the right, but that the subsequent portions
less and less of this power, and finally none.

Ohme's rectified bergamot-oil is not altered by caustic potash. Its vapo
over red-hot lime yields a large quantity of benzene. It absorbs hydrochl

dantly, forming a liquid compound, which, after being shaken up and distilled er, has the specific gravity 0·896; boils at 183° C., and contains $C^{60}H^{100}Cl^2O$, ^{16}.2HCl.H^2O.

mot-oil placed in contact with phosphoric anhydride becomes heated, and ls yields by distillation an oil smelling like oil of turpentine, and having he composition $C^{10}H^{16}$. The residue of the distillation contains a conjugated *sphobergamic acid*, which forms soluble salts with calcium and lead.

MOT-CAMPHOR, *Bergaptene*, *Stearoptene of bergamot-oil*, is a solid sub- eposited by crude oil of bergamot after long keeping. It crystallises in melts at 206° C., and volatilises without decomposition. It is odourless and in boiling water, alcohol, and ether. Strong sulphuric acid colours it red. ith nitric acid, it yields oxalic acid. It gives by analysis about 66·2 per cent. nd 3·8 hydrogen, numbers answering to the formula $C^3H^4O^2$, but the ra- mula is not yet determined. (Mulder, Ann. Ch. Pharm. xxxi. 70; Ohme,

THIERIN. The name given by Beudant to a ferruginous mineral occurring grains, resembling iron-spar or brown iron ore; but whether it is a definite r a mixture is not decidedly known. According to Berthier, it contains 12·4 silica, 74·7 protoxide of iron, 7·8 alumina, and 5·1 water. The same name plied to a mineral from Hayanges near Metz, of greyish-green or liver-brown which, under the microscope, appears like an oolitic rock, consisting of a amorphous mass, containing innumerable small flattened needles of brown

THIERITE or **HAIDINGERITE.** These names are applied some- iscriminately to three minerals, containing protosulphide of iron, together ulphide of antimony. — *a.* $3Fe''S.2Sb^2S^3$. Found at Chazelles in Auvergne, ne or massive, with imperfect cleavage in several directions. Specific gravity ardness 2·0 to 3·0. Iron-black or dark steel-grey. Opaque with metallic Fuses readily before the blowpipe on charcoal, yielding antimonial fumes sit, and leaving a black magnetic slag (Berthier, Ann. Ch. Phys. [2] xxxv. $3Fe''S.4Sb^2S^3$. Found in a mine near Chazelles. Fibrous, with granular e fracture, almost destitute of lustre (Berthier, Pogg. Ann. xxix. 458).— b^2S^3. Found at Anglar in the Département de la Creuse. Crystalline, com- fine parallel fibres. Steel-grey, inclining to bronze (Berthier). Minerals his composition are also found in other localities.

THOLLETIA EXCELSA. A Brazilian tree belonging to the order *Lecy-* The kernels of the fruit, called Brazilian or Para nuts, contain sugar, gum, le yellow odourless fat oil, which solidifies at 0° C., and contains stearin, and elain. (Caldwell, Ann. Ch. Pharm. xcviii. 120.)

YL. $3Gl''O.Al^2O^3.6SiO^2 = Gl^3Al^2Si^6O^{18}$.—A mineral species comprising arieties, among which are found two very beautiful and costly gems, viz. *emerald*, *marine* or *precious beryl*. The crystals belong to the hexagonal system, being x-sided prisms variously modified, sometimes by the truncation of the lateral other times of the terminal edges. The most ordinary combinations are and ∞P . oP . P. (*fig.* 98); sometimes, however, much more complicated ions occur, like *fig.* 99, composed of the hexagonal prism ∞P. the terminal the primary hexagonal pyramid P, a sharper hexagonal pyramid of the first a pyramid of the second order 2P2, and a symmetrical 12-sided pyramid ose faces (denoted in the figure by *z*) replace the combination-edges between ∞P. The prismatic faces are often deeply striated in the vertical direc-

Fig. 98.

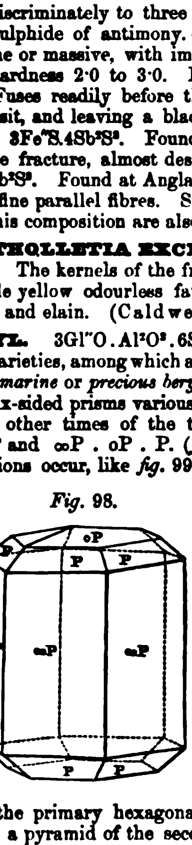
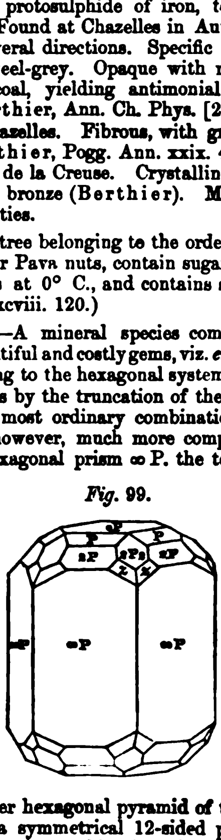


Fig. 99.



tion. Cleavage tolerably perfect, parallel to oP. Fracture conchoïdal and
Specific gravity 2·67 to 2·76. Hardness 7·5 to 8·0. The most usual colour
beryl is green, of various shades between yellow- and blue-green, arising fr
presence of iron in various stages of oxidation; yellow, blue, rose-coloured,
lourless beryls are also found. The brilliant green of the emerald is due
presence of oxide of chromium. Lustre vitreous. The best specimens of
and aquamarine are perfectly transparent; but the transparency is generally
diminished by cracks and striæ, the coarser varieties being opaque in the m
translucent only at the edges. Beryl is difficult to fuse by itself before the bl
melting to a glass at the edges only; with borax it fuses readily to a tran
glass; with phosphorus-salt, it leaves a skeleton of silica.

Beryl from Limoges was found by C. Gmelin to contain 67·54 SiO^2, 17·63 Al
13·51 $Gl''O$ (= 98·68); a specimen from Fahlun, analysed by Berzelius, gav
SiO^2, 17·60 Al^2O^3, 13·13 $Gl''O$, 0·72 Fe^2O^3 and 0·72 TaO^2. These and nu
other analyses agree nearly with the formula above given (calc. 67·46 SiO
Al^2O^3, 13·80 $Gl''O$), which, by substituting *al* = ⅔Al, may be reduced to th
metasilicate $(Gl''al'')Si^2O^6$.

Beryls are found in various parts of the world; the finest emeralds com
Peru, where they are found traversing clay-slate, hornblende slate, and grani
specimens are also obtained from Katharinenburg in Siberia; inferior variet
the Heubach valley in the district of Pinzgau in Salzburg; varieties are als
in some old mines in Mount Zabarah in Upper Egypt, from which spot the
are supposed to have derived their emeralds. Fine transparent beryls o
marines are found in Brazil, in the granite district of Nertschinsk in Siberia
Ural and Altai mountains, and in the granite of the Morne mountains in the c
Down, Ireland. Opaque beryls, sometimes of very large size, are found at Lang
in Silesia; at Bodenmais in Bavaria, near Limoges in France; at Kinloch, R
and Cairngorm, Aberdeenshire; and in the counties of Dublin and Wicklow.
the Connecticut and Marimac rivers, near Crofton in North America, ex
specimens have been found, measuring from 4 to 6 feet in length, and weighing
2000 and 3000 pounds.

BERYLLIUM. Syn. with GLUCINUM.

BERZELIANITE. Selenide of Copper.

BERZELIITE. *Berzelite, Kühnite, Chaux arseniatè anhydre, Magnesia*
macolite. $As^4(Mg^2Ca^3)O^{16}$.—A massive mineral occurring near Langbansh
Sweden. It has an uneven fracture, and exhibits traces of cleavability in on
tion. Yellowish-white to honey-yellow, with waxy lustre; translucent on th
Perfectly soluble in nitric acid. Before the blowpipe, it exhibits the usual r
of arsenic, and with soda shows evidence of a trace of manganese. (Kühn, A
Pharm. xxxiv. 271.)

BERZELIN. A mineral found in the older volcanic ejections near Lake
in Italy, together with hauyne, augite, and mica. It crystallises in octahe
dodecahedrons, belonging to the regular system, sometimes forming twin-c
cleavage tolerably distinct, parallel to the faces of a cube. The crystals a
uneven and rounded. It occurs also in spherical and stalactitic forms, mas
imbedded. Fracture varying from conchoïdal to uneven; colour white or grey
vitreous to dull; varies from transparent to perfectly opaque; streak white
ness 5·0; specific gravity 2·428 to 2·727. According to an imperfect anal
L. Gmelin, its composition is similar to that of leucite. When pulverised and
it yields a small quantity of water. Melts with difficulty before the blowpi
tumefied glass; with borax readily to a clear glass. Dissolves slowly in nit
yielding a jelly of silica when heated. Similar crystals have been found in n
dolerite from Meiches in Oberhessen. (Handw. d. Chem. ii. [1] 1023.)

The same name has been applied to native selenide of copper.

BERZELITE. This name has been given to Mendipite, Petalite, Thor
Berzeliite.

BETA. *Beet.*—A genus of plants, belonging to the natural order Chenopo
distinguished by the large quantity of sugar contained in their roots. Th
principal species are:—1. *Beta vulgaris*, common beet, well known for its sweet
roots, which are used as a salad.—2. *Beta cycla*, chard beet, inferior in the s
flavour of its roots, but distinguished by its remarkably thick-ribbed leaves, w
used in France in soups; or the ribs only are cut out and stewed like sea
3. *Beta altissima*, field-beet or mangold-wurzel, sometimes, though erroneously,
as a hybrid between the two former. This is by far the most important speci
is extensively cultivated for feeding cattle, and in France and Germany also
extraction of sugar.

oot of mangold-wurzel contains crystallisable sugar, identical in every respect
ne-sugar. Payen gives for the average composition of the root, 83·5 per cent.
0·5 sugar, 0·8 cellular substance and pectose, 1·5 nitrogenous matter (albumin,
d 3·7 pectin and salts. The salts consist of nitrates and ammonium-salts, toge-
h alkaline and earthy phosphates, sulphates, chlorides, oxalates and malates, or,
g to some chemists, citrates. The root has also been stated to contain two or
eculiar acids, which have not been thoroughly examined. The dried leaves
, according to Sprengel, 15·44 per cent. ash. The seed contains 11·6 per cent.
and in 100 pts. of dry substance, 0·09 sulphur and 6·58 ash. (Way and
n.)

ollowing table exhibits the composition of the ash of the seed, leaves, and roots:—

	Ash of seed.	Ash of leaves.	Ash of roots.	
	Way.	Ogston.	Sprengel.	Ettl.
a (anhydrous) . . .	16·1	36·3	23·9	19·5—26·6
„ . . .	6·8	21·3	53·1	22·4—30·5
. . . . . .	13·4	14·9	4·8	3·2— 4·5
esia	15·2	5·4	2·2	7·0— 9·8
na and ferric oxide . .	0·4	1·1	2·3	0·1— 0·1
anic oxide	1·8	0·4		
. . . . . .	—	2·7	1·8	14·1—19·8
uric acid (anhydrous) . .	3·6	6·3	2·1	2·5— 2·5
horic „ „ . .	13·1	4·5	2·8	2·4— 2·4
ne	—	6·9	6·3	1·4— 1·9
nic acid (anhydrous) . .	13·8			
de of sodium . . .	15·3			

TULIN. $C^{40}H^{64}O^3$.—A resinous substance extracted from the outer bark of
ch-tree (*Betula alba*), or from the tar prepared therefrom. It was discovered
witz (Crell. Chem. Ann. 1788, i. 302), and analysed by Hess (J. pr. Chem. xvi.
It belongs to the series of resins, including sylvic acid, which are produced by
on from hydrocarbons of the form $C^{4n}H^{6n}$. To extract it, the dried bark is ex-
d with boiling water, then dried again and treated with boiling alcohol. The
n on cooling deposits the betulin, which is pressed, dried, and recrystallised
ther. It forms small crystalline nodules, which melt at about 200° C. The
matter is colourless and transparent, and gives off vapours which smell like the
hen heated. It may be distilled in a current of air. It is not dissolved by alkalis.

TULORETIC ACID. According to Kossmann (J. Pharm. [3] xxiv. 197)
esin consists of an acid, $C^{36}H^{58}O^5$, which is converted by nitric acid into picric
ut is not decomposed by sulphuric acid.

UDANTIN. See NEPHELIN.

UDANTITE. A ferruginous mineral occurring at Horhausen and Montabaur
sau, and near Cork in Ireland. It crystallises in rhombohedrons cleavable
l to the base, and having the rhombohedral faces horizontally striated. Colour
to olive-green. Streak light green. The fresh crystals have a waxy lustre.
ess above 4·0. The Nassau mineral has a specific gravity of 4·0018, and melts
before the blowpipe (Sandberger). The Irish variety has a specific gravity of
and is infusible (Rammelsberg). It contains sulphate of lead, associated with
sulphate, arsenate, and phosphate, the two latter replacing each other isomor-
y; it also contains water (Pavy, Phil. Mag. [3] xxxvii. 161). According to
nelsberg, it is $2(Pb''O.SO^3) + Fe^2O^3.SO^3 + 3F^2O^3.P^2O^5 = 9H^2O$; according to
berger, $Pb''O.SO^3 + 3Pb''O(As^2O^5; P^2O^5) + 3[3Fe^2O^3(As^2O^5; P^2O^5)] + 24H^2O$.
w. d. Chem. ii. 1029.)

ZETTA. *Tournesol en drapeaux.* *Schminkläppchen.* *Bezetta rubra et*
.—A dye or pigment prepared by dipping linen rags in solutions of certain co-
matters. Red bezetta is coloured with cochineal, and is used as a cosmetic.
bezetta (*Tournesol en drapeaux*), which is chiefly used for colouring the rind
ch cheeses, is prepared at Gallargues near Nîmes in the department of Gard,
euphorbiaceous plant, *Chrozophora tinctoria* or *Croton tinctoria*. The fruits
s tops of the plants are gathered, and the juice being expressed, rags of coarse
re dipped into it, then dried, and afterwards exposed to the fumes of mules' or
dung. This last operation is called *aluminadou*. The cloths are turned from
time, to ensure uniform coloration and prevent any part from being exposed

too long to the fumes of the dung, which would turn them yellow. They are then dried a second time, again soaked in the juice, mixed this time with urine, and lastly exposed for some time to the action of the sun and wind. The quantity thus manufactured amounts to about 50 tons yearly. The blue of bezetta is reddened by acids like litmus, though not so quickly, but differs from the latter in not being restored by alkalis. According to Joly, the same dye may be obtained from other euphorbiaceous plants, *Chrozophora oblongata*, *C. plicata*, *Croton tricuspidatum*, *Mercurialis perennis*, and *M. tormentosa*. The juice exists in all these plants in the colourless state, and turns blue only on exposure to the air. (Handw. d. Chem. ii. [1] 1030; Gerh. Traité, iii. 820.)

BEZOAR. This name, which is derived from a Persian word implying an antidote to poison, was given to a concretion found in the stomach or intestines of an animal of the goat kind, *Capra ægragus*, which was once very highly valued for this imaginary quality, and has thence been extended to all concretions found in animals.

According to Taylor (Phil. Mag. No. 186 p. 36 and No. 186 p. 192), bezoars may be divided into nine varieties:—1. Phosphate of calcium, which forms concretions in the intestines of many *mammalia*.—2. Phosphate of magnesium: semitransparent and yellowish, and of specific gravity 2·160.—3. Phosphate of ammonium and magnesium: a concretion of a grey or brown colour, composed of radiations from a centre.—4. Oxalate of calcium.—5. Vegetable fibres.—6. Animal hair.—7. Ambergris.—8. Lithofellic acid.—9. Ellagic or bezoardic acid.

Of true bezoars there are three kinds, *oriental*, *occidental*, and *German*. The true oriental bezoars found in the *Capra ægragus*, the gazelle (*Antilope Dorcas*), and other ruminant animals, are spherical or oval masses, varying from the size of a pea to that of the fist, and composed of concentric layers of resinous matter with a nucleus of some foreign substance, such as pieces of bark or other hard vegetable matter which the animal has swallowed. They have a shining resinous fracture, are destitute of taste and odour, nearly insoluble in water and aqueous hydrochloric acid, but soluble for the greater part in potash-ley. When heated, they emit an agreeable odour and burn away, leaving but a small quantity of ash. These characters suffice to distinguish the oriental bezoars from those varieties which contain a considerable quantity of inorganic matter. There are two kinds of them, the one consisting of ellagic, the other of lithofellic acid. The latter have a more waxy lustre and greener colour than the former, and are also distinguished by their smaller specific gravity, viz. 1·1, while that of the ellagic acid stones is 1·6. They contain, besides lithofellic acid, a substance resembling the colouring matter of bile, and are perhaps biliary calculi. Oriental bezoars are greatly prized in Persia and other countries of the East for their supposed medicinal properties. The Shah of Persia sent one in 1808 as a present to Napoleon.

The occidental bezoars are found in the lama (*Auchenia Lama*), and in *A. Vicunna*: they resemble the oriental in external appearance, but differ totally in their chemical characters, inasmuch as they consist chiefly of phosphate of calcium, with but little organic matter.

German bezoars, which are chiefly obtained from the chamois or gemsbock (*Antilope rupicapra*), consist chiefly of interlaced vegetable fibres or animal hairs bound together by a leathery coating.

BEZOARDIC ACID. Syn. of ELLAGIC ACID.

BEZOARDICUM ANIMALE. An antiquated medicament made from the dried hearts and livers of vipers, and supposed to be an antidote against poison: hence its name.

BEZOARDICUM MINERALE. A name applied by the older chemists to antimonic acid, especially to that prepared from butter of antimony by the action of nitric acid.

BI-COMPOUNDS. See DI-COMPOUNDS and NOMENCLATURE.

BILDSTEIN. Syn. with AGALMATOLITE.

BILE. *Gall. Galle.* (Lehmann, "Physiological Chemistry," Cavendish Society's Edition, ii. 61; also Gmelin's Handbuch, viii. 38. Strecker, Ann. Ch. Pharm. lxv. 1; lxvii. 1; lxx. 149. Gundelach and Strecker, *ibid.* lxii. 205).—Bile, as secreted by the cells of the liver, is taken up by the biliary ducts, which unite to form the hepatic duct, by which the secretion is either discharged directly into the duodenum, or is conveyed through the cystic duct into the gall-bladder, wherein it becomes accumulated and to some extent inspissated. Cystic bile when taken from a healthy animal recently killed, is a mucous, transparent, ropy liquid, of green or brown colour. It has a bitter but not astringent taste, sometimes leaving a sweetish after-taste, and a peculiar odour, which, when the bile is warmed, is often very much like that of musk.

fic gravity is about 1·02. It does not diffuse itself readily through water, e mixture be stirred. Its reaction is, for the most part, faintly alkaline, some-utral, never acid, excepting in peculiar states of disease. Bile in its ordinary fore the mucus is removed, putrefies very readily; but when freed from mucus, h less prone to putrefactive decomposition.

hemical composition of bile varies to a certain extent according to the nature imal which yields it; but every kind of bile contains two essential constituents, sinous and a colouring matter, associated with small quantities of cholesterin, s of fatty acids, and certain mineral salts, chiefly chloride of sodium and es, with smaller quantities of phosphate and carbonate of sodium, phosphate m, phosphate of magnesium, and extremely minute quantities of iron and se, but no alkaline sulphates. No salts of ammonia are found in fresh healthy during the putrefaction of bile, ammonia is produced. Bile also contains ixed with cells of epithelium.

esinous matter of bile is the most abundant and important of its consti-It consists, in nearly all cases, of the sodium or potassium salts of two nitro-acids, one containing sulphur, the other free from that element. The former acids, called taurocholic acid, is resolved by the action of alkalis into nd *cholic acid*, a crystalline acid containing neither nitrogen nor sulphur, and , under certain circumstances, into an amorphous isomeric acid called cho-cid, differing from it only by the elements of water:

$$\underset{\text{Taurocholic acid.}}{C^{26}H^{45}NSO^{7}} + H^{2}O = \underset{\text{Cholic acid.}}{C^{24}H^{40}O^{5}} + \underset{\text{Taurine.}}{C^{2}H^{7}NSO^{3}};$$

atter, called glycocholic acid, is resolved in like manner into cholic acid *ocine:*

$$\underset{\text{Glycocholic acid.}}{C^{26}H^{43}NO^{6}} + H^{2}O = \underset{\text{Cholic acid.}}{C^{24}H^{40}O^{5}} + \underset{\text{Glycocine.}}{C^{2}H^{5}NO^{2}}$$

nds of bile, excepting that of the pig, contain one or both of these acids. Pig's ains an acid called glyco-hyocholic acid, analogous to glycocholic acid, that compound, resolvable by the action of alkalis into glycocine and hyocholic acid not containing nitrogen:

$$\underset{\text{Glycohyo-cholic acid.}}{C^{27}H^{43}NO^{5}} + H^{2}O = \underset{\text{Hyocholic acid.}}{C^{25}H^{40}O^{4}} + \underset{\text{Glycocine.}}{C^{2}H^{5}NO^{2}}.$$

olouring matter of bile, *bile-pigment*, or *cholochrome*, is also a nitrogenised is decomposed by nitrous acid, with evolution of nitrogen and formation of a ed acid, *cholochromic acid*, which is free from nitrogen. (Thudichum, oc. Qu. J. xiv. 114.)

le of carnivorous and omnivorous animals, including man, contains a brown the *cholepyrrhin* of Berzelius: that of birds, fishes, and amphibia has usually e green pigment, *biliverdin*. The brown pigment is always combined either a or with lime; in the latter case, it is insoluble, and appears in the form of anules when the bile is examined by the microscope.

alysis of bile is conducted as follows:

le is first mixed with half its volume or more of 83 per cent. alcohol, which own mucus and epithelium; the precipitate is rinsed with spirit, then er, afterwards dried and weighed.

ile thus freed from mucus, is evaporated to dryness, first over the water-bath under the air-pump on a sand-bath heated to 100° C.; the residue is left to acuo, after which, air dried by passing over chloride of calcium is introduced receiver, and the weighing is completed as quickly as possible, because the e is extremely hygroscopic.

sidue is next digested for a considerable time with *ether*, which takes up fat lesterin. The total quantity of these matters may then be determined by ng the ethereal extract; but the different substances contained in it cannot be y estimated, unless very large quantities of bile are operated upon; in that fatty acids (stearic and margaric or palmitic acids) may be separated from sterin by precipitation as lead-salts.

sidue insoluble in ether, which contains the essential constituents of the bile, be treated with cold *absolute alcohol*, which dissolves the salts of the biliary ether with part of the bile-pigment; the greater part of the alcohol is then re-y evaporation; ether added to the concentrated solution as long as any tur-produced; and the liquid left to stand for some time in a cool place.

lkaline taurocholate and glycocholate are thereby precipitated, and

their quantity may be estimated by washing the precipitate with ether, and
it after drying over the water-bath. It always, however, contains a certain
bile-pigment, which cannot be completely separated unless it consists of p
pyrrhin, in which case it may be separated by chloride of calcium. The qu
soda or potash associated with the biliary acids and the bile-pigment
determined by decomposing a weighed portion of the ether-precipitate with
acid.

The taurocholic and glycocholic acids cannot be completely separated one
other. An approximate separation may be effected by dissolving the prec
alcohol, and treating it with neutral acetate of lead, which precipitates only
cholic acid; but the best way of estimating the relative quantities of the tw
to determine the amount of *sulphur* in the ether-precipitate, by fusing it wit
by one of the other methods given under **ANALYSIS** (**ORGANIC**), p. 225. Ever
sulphur correspond to 100 pts. of taurocholate of sodium.

The residue of the bile, insoluble in absolute alcohol, must now be determine
view of checking the analysis. It contains pigment, partly free and partly
with lime; also alkaline and earthy phosphates, with chloride and car
sodium, very rarely sulphate of potassium, but often a little taurine; its
generally too small to allow of the quantitative separation of these substanc
very large quantities of bile are operated upon. Altogether the determinati
have been made of the amount of pigment, cholesterin, fats, fatty acids, an
constituents of bile, cannot be regarded as more than approximations to the

Pettenkofer's Test for Bile.—When bile is mixed with a strong syrup of
then with strong sulphuric acid, so that it becomes heated, it assumes a deep
or purple tint, which disappears on addition of water. This reaction is pr
cholic, choloidic, glycocholic, and taurocholic acids (or the corresponding aci
bile), but not by any other substance; it is, therefore, perfectly characterist
and affords a very delicate indication of its presence. The best mode of a
for the detection of small quantities of bile in blood or other animal flu
follows:—The alcoholic extract of the liquid to be tested for biliary matter, is
in a little water, and mixed with a single drop of a solution of sugar (1 pt. of
4 pts. of water), and pure strong sulphuric acid is then added by small quan
the turbidity at first produced, disappears, cooling after each addition; it t
few moments exhibits a yellowish colour, which, however, soon changes to a p
red, then to deep carmine, then to purple, and finally to an intense violet
the success of the experiment, care must be taken not to add too much sug
wise a black mass will be formed, which will completely mask the react
temperature of the mixture must be allowed to rise to about 50° C. but n
The reaction takes place with any kind of sugar, and likewise with acetic ac

Composition of the Bile of various animals.—*Human bile* consists mainly
chlorate of sodium, with very little glycocholate (Gorup-Besanez). *O*
the contrary, contains chiefly glycocholate (Strecker). *Pig-bile*, as a
served, consists mainly of the sodium-salt of an acid analogous to glycocholic
glycohyocholic acid (Gundelach and Strecker), together with a sma
of a sulphuretted acid, yielding taurine by decomposition: *tauro-hyochol*
likewise contains a very strong base containing sulphur.

The bile of most other animals consists mainly of taurocholate of sodium
sium. That of the *dog* contains only taurocholate of sodium; that of the
that of the *kangaroo* contain taurocholate, with very little glycocholate. I
of several kinds of fish, viz. *turbot*, *cod*, *pike*, and *perch*, Strecker found tau
with mere traces of glycocholate; a similar result was obtained by Schlo
(Ann. Ch. Pharm. cviii. 166) with the bile of the *shad-fish*. According to
(Ann. Ch. Pharm. lxv.) and Strecker, the bile of *sea-fish* contains potass
that of *fresh-water fish* chiefly sodium-salts. The bile of the *Boa Anaconda*
per, Ann. Ch. Pharm. lx. 109) and that of the *Python tigris* (Binder, *ib*
consist mainly of taurocholate. *Goose-bile* appears likewise to consist ess
taurocholate of sodium, though Marrson (Arch. Pharm. [2] lviii. 138),
recently Heintz and Wisliscenus (Pogg. Ann. cviii. 547) state that the su
acid of goose-bile differs in composition from taurocholic acid; Heintz
liscenus assign to it the composition $C^{29}H^{49}NSO^{6}$; but the analyses are
satisfactory.

Taurocholate of sodium contains about 6 per cent. of sulphur: now in
bile of the dog, Bensch found 6·2 per cent, sulphur; in that of the fox, 5·96
of the wolf 5·03; of the bear 5·75; of the pig 0·32; of the calf 5·62; of the she
the goat 5·99; of the domestic fowl 5·57; and of several fishes 6·46 per cent.

In normal human bile, Frerichs found 14 per cent. or rather more of sol
tuents; Gorup-Besanez, in the bile of two recently executed criminals, fo

r cent. solid matter; in that of an old man, 9·13 per cent; and in that of
elve years old, 17·19 per cent. solid matter. Ox-bile contains 10·13 per
onstituents; pig's bile 10·6 to 11·08 per cent. (Gundelach and Strecker);
1 per cent.; cat's bile 5·6 per cent. (Bidder and Schmidt); sheep's bile
bile 1·8; goose bile 6·9; kangaroo's bile 14·13; and crow's bile 7·3; per cent.
uents. The concentration of the bile appears to increase with the time it
he gall-bladder.

ortion of *ash* in the dried residue amounts in normal human bile to 6·14
orup-Besanez), in ox-bile to 12·7 (Berzelius); in calf's bile to 13·15
in sheep's bile to 11·86; in goat's bile to 13·21; in pig's bile to 13·6; in
12·71; in that of the domestic fowl to 10·99; in that of fresh-water fish,
cent.; in that of the fresh-water turtle (*Emys geographica*) to 5·5; and in
alt-water turtle (*Emys insculpta*) to 6·3 per cent. (Wetherill, J. pr. Chem.
The fresh bile of *Python tigris* yields 1·21 per cent. of ash.

xtracted from the gall-bladder without pressure, contains 0·134 per cent.
an-bile 0·158 per cent. (Lehmann); Gorup-Besanez found in human bile
21 per cent. *mucus* and *bile-pigment*. The bile of the kangaroo contains
nt. *mucus* and *colouring matter*, and 1·09 *cholesterin* and *fat;* that of the
ntains 1·28 per cent. *mucus* and *colouring-matter*, and 0·23 per cent. *fat;*
hon tigris, contains 0·89 per cent. *mucus* and 0·03 *fat;* goose-bile contains
nt. mucus, 0·36 *fat* and *cholesterin*. (Marrson.)

like all the other normal secretions, is liable to alteration from disease, and
contains heterogeneous constituents. *Albumin* is sometimes found in it,
n fatty liver, in Bright's disease, and in the embryonic state. *Urea* has
in the bile, in cases of fatty degeneration of the kidneys, and in animals
eys have been extirpated; also in cholera. Bizio once discovered a dark-
ter bile in a patient suffering from jaundice; it contained an emerald-
ent, to which he gave the name of *erythrogen*, from its volatilising at 40° C.
off a red vapour. A similar substance was found by Lehmann in a case of
atrophy of the liver. In the bile of a child who died suddenly, Lehmann
siderable quantity of *sulphide of ammonium*, but the previous history of the
t known.

nal constituents of the bile also vary in proportion, in various cases of
he bile has been found to be poor in solid constituents, in persons who have
severe inflammatory affections, especially from pneumonia, and likewise in
of dropsy; it also contains an excess of water in diabetes, and in certain
hus; in other cases of that disease, however, the bile becomes thicker than
The solid constituents of the bile are commonly *increased* in those abdo-
ses in which the motion of the blood in the larger veins is impeded, and in
es of heart-disease, in which the blood accumulates in excessive quan-
hepatic veins. In cholera, the bile is also found to be dense, tough,
ent. The proportion of *mucus* is often increased when the bile is very
leed in typhus, the gall-bladder sometimes contains scarcely anything
sinous constituents being almost, if not altogether absent; the same is
catarrh of the biliary ducts. (Lehmann.)

ration of *crystals of cholesterin*, which is sometimes, though rarely, observed
bile, appears to be associated with an increase in the relative quantity of
nce; this phenomenon has been observed by Gorup-Besanez in very con-
ile. *Free fat* is always present in the bile, but in the normal state is held
by the taurocholate of sodium; fat globules have, however, been observed
Besanez in the bile of persons who have died from typhus, and from tuber-
he colliquative stage. (Lehmann.)

is very seldom *acid;* an acid reaction has been observed in typhus, but it
arisen partly from spontaneous decomposition after death, partly from
pus into the gall-bladder: for pus, when contained in an enclosed space,
nes acid with great rapidity. (Lehmann.)

tion of Bile.—When bile is left to itself, either in a closed or in an open
ndergoes gradual decomposition, acquiring an offensive odour and acid re-
l yielding a solid deposit containing cholic acid and other substances.
m (Chem. Soc. Qu. J. xiv. 118) found that ox-bile left for a year cr
ge bottles, well stoppered, and completely filled with it, had assumed a
reaction, a bright port wine colour, and had deposited a copious, flaky,
brown deposit, mixed with white chalk-like particles and greenish crystals.
it was found to consist of cholochrome (bile-pigment), cholic acid, phos-
cium and magnesium in dichroic crystals, and mucus. The fluid part of the
und to contain principally choloidate of sodium with a little cholate; also
erate and acetate of sodium, and of ammonium, and phosphate of sodium,

but no glycocine, glycocholic acid, or taurocholic acid. The decompositio
to begin by the resolution of the glycocholate of sodium into cholate of so
glycocine, and of the taurocholate into cholate and taurine. The ammonia a
acid are probably formed by the decomposition of the glycocine (oxyacetan
the origin of the valeric acid is obscure; these acids unite with a portion o
and precipitate some of the cholochrome and cholic acid, the rest of that aci
ing in solution as choloidate of sodium. From the experiments of Gorup-
(Ann. Ch. Pharm. lix. 129) it appears that bile allowed to decompose in
vessel, at a comparatively high temperature, 25° to 30° R., deposited chiefly
acid, but when the decomposition took place in a cellar at 10° to 12°
acid was deposited instead of choloidic, the higher temperature favouring t
formation of cholic acid into its amorphous modification.

Human bile putrefies much in the same manner as ox-bile; but the actua
are usually modified by the decomposition of the albumin which is present in
the bile that can be obtained for examination, viz. the bile of persons who
of disease, and usually not obtained till some days after death. The alkaline
resulting from the decomposition of the albumin partially neutralise the acid
of the decomposition of the bile, and thereby prevent, to a certain extent, the
of insoluble compounds. (Thudichum.)

Biliary calculi, or *Gall-stones.*—These concretions in man sometimes consi
of chlolochrome, held together by some binding material, generally suppo
mucus, or inspissated bile, but consisting, according to Thudichum (*loc. cit.*
or choloidic acid, or both. In most cases, a small nucleus of this character
and becomes coated with cholesterin, which then forms the chief mass of the c
Earthy phosphates and carbonates are likewise present. Ox gall-stones cons
of cholochrome, cholic acid, and choloidic acid, with small portions of choles
unaltered bile mechanically enclosed: they also contain the phosphates and c
of calcium and magnesium, and an ammonia-compound, possibly sulphide
nium (Thudichum). The formation of these calculi is attributed by Thudic
decomposition of the bile, similar to the putrefaction which takes place whe
moved from the gall-bladder. (See GALL-STONES.)

BIMSTEIN. See PUMICE-STONE.

BINARY THEORY OF SALTS. The theory which regards salt
pounds of a metal with an acid or chlorous radicle: *e.g.* acetate of pot
$C^2H^3O^2.K$: nitrate of potassium, $NO^3.K$, &c. (See ACIDS.)

BINNITE. A native sulpharsenite of lead, from the Binnenthal in t
where it is found imbedded in white granular dolomite. It sometimes form
prismatic crystals, belonging to the rhombic system, but more frequently, br
like, crystalline aggregations, or crude masses: it is very brittle and friable
steel-grey to iron-black, or light lead-grey, with strong metallic lustre. Opaqu
reddish-brown. Hardness, 2·5 to 3·0. Specific gravity 5·0 to 5·5. Its co
appears to be liable to some variation. According to Waltershausen, it is a r
variable proportions of *arsenomclane*, $Pb''S.As^2S^3$, and *scleroclase*, 2P
(Handw. d. Chem. ii. [1] 1099.)

BIOTIN. Syn. with ANORTHITE.

BIOTITE. Uniaxial or Magnesia Mica. See MICA.

BIRCH. (*Betula alba.*)—The *bark* of this tree contains, according to J
pert. Pharm. xxxiii. 327), one-third of its weight of resin, and a considerable
of tannin, whence it is used for tanning leather, and for black-dyeing, especial
The white, easily separated epidermis of birch-bark, contains resin, tannic
tractive matter, and ash, consisting chiefly of sesquioxide of iron, silica, a
The red-brown bark on the lower parts of the stem of an old tree, yields by s
treatment with ether, alcohol, and aqueous potash, a resin, $C^{20}H^{30}O^2$, soluble
a red-brown colouring matter, $C^{10}H^8O^2$, soluble in alcohol, and another red-br
stance, $C^{20}H^{18}O^9$, soluble in alkalis, and precipitated by acids. (Stahelin an
stetter, Ann. Ch. Pharm li. 79.)

The *leaves* of the birch contain, according to Grossmann, 0·3 per cent. ess
and wax, besides tannin, and a bitter yellow colouring matter. They are used
in northern countries.

The dry *wood* of the birch contains, according to Karsten, 0·25 to 0·3 per c
according to Berthier 1·0 per cent. Berthier found also in 100 pts. of the as
of soluble and 84 pts. of insoluble salts. Wittstein (Pharm. Centralb. 1851
has analysed the ash of birch-wood growing on different soils: viz. *a.* on
gonitic soil of Akareyri in Iceland, composed of weathered volcanic rock
the sterile calcareous soil of Morschen in Kurhessen, belonging to the Mu

n the sandy soil of Marburg in Kurhessen, belonging to the sandstone

a	b	c		a	b	c
12·8	5·7	14·8	SO^3 . .	0·02		
1·6	1·2	2·8	SiO^2 . .	2·9	1·5	4·0
26·7	46·9		CO^2 . .	18·8	24·6	12·9
2·2	1·7	11·8	P^2O^5 . .	8·1	4·2	16·6
1·4	0·4		H^2O . .	4·1	7·1	9·8
0·8	0·4		Charcoal .	0·6	0·4	0·5
trace	1·7	3·8	Sand .	19·8	2·4	4·7

s.—The fungus of the birch-tree contains woody fibre, phoblaphene (a
contained in pine-bark), fat, a bitter principle, uncrystallisable sugar,
id, tartaric acid, and citric acid. It yields 15·3 per cent. water, and
h, containing in 100 pts.: 5·0 K^2O; 4·1 Na^2O; 48·8 CaO; 5·5 MgO;
Fe^2O^3; 4·4 SO^3; 0·6 Cl; 15·6 P^2O^5; 4·7 SiO^2; 15·9 CO^2. (J. Wolff,
ft f. prakt. Pharm. iii. 1.)

Birch-water.—This liquid is obtained, like the juice of the maple,
ems of the trees in February and March. A tree of average size yields
juice, consisting chiefly of sugar, together with nitrogenous substances
s, including acid tartrate of potassium. It easily ferments, and quickly
exposed to the air. In some localities, as in the Harz, in Courland,
it is used for the preparation of an effervescent wine.

All parts of the birch-tree appear to contain an essential oil. The
d buds yield, by distillation with water, a colourless oil, which gradually
the air, has the aromatic odour of newly developed birch-leaves, and a
sweetish at first, afterwards balsamic and burning. It is mobile at
viscid at 0°, and solidifies to an amorphous mass at −10°. It dis-
l more readily than in ether: water is said to extract a stearoptene (?)
ssmann, Répert. Pharm. xxiii. 327.)
he *Betula lenta*, a North American tree, yields an essential oil identical
tergreen (salicylate of methyl): it does not however exist in the bark
ut is produced from a crystalline substance, *gaultherin*, contained in the
tion of a ferment in presence of water, in the same way as bitter-almond
alin. (Procter, Amer. J. Pharm. Jan. 1844.)

See **Betulin.**

Dagged. Black Doggert or *Deggelt. Birch-tar Oil.*—In Russia and
countries, the bark of the white birch is subjected to a kind of down-
on, in conical pits 20 or 25 feet deep, covered over first with a roofing
en of turf and mould, having holes to regulate the admission of air, as in
ilers. By this process, two products are obtained, namely, charcoal and
mounting to 60 or 70 per cent. of the bark. It is a brown-black viscid
coating wood, and also for lubricating carriage wheels, as it remains
very low temperatures.
n distilled yields a brown strong-smelling acid oil, and on rectifying
d hydrocarbon, having the composition of oil of turpentine, passes over
ed with an oxygenated oil, the proportion of the latter gradually in-
distillation advances. The oxygenated oil may be removed by potash-
ydrocarbon, $C^{10}H^{16}$, is left behind. Its smell is like that of oil of
more agreeable, recalling that of birch-bark. Specific gravity 0·87
ls at 156°. Vapour-density 5·2 (calculation 2 vols. 4·8). At −16° it
l quantity of stearoptene. Sparingly soluble in water, readily in alcohol
absorbs oxygen rapidly from the air, giving off carbonic anhydride, and
l into a resinous mass. It is also oxidised by nitric acid, giving off
d, and yielding two acid resins. It absorbs 32 per cent. chlorine, with-
rystalline compound. Betulin is perhaps formed from this hydrocarbon
(Sobrero, J. Pharm. [3] ii. 207.)

e. The best birdlime is made of the middle bark of the holly, boiled
hours in water, till it is soft and tender; then laid in heaps in pits in
covered with stones, the water being previously drained from it; and
t for two or three weeks to ferment, till it is reduced to a kind of muci-
ng taken from the pit, is pounded in a mortar to a paste, washed in
d kneaded, till it is free from extraneous matters. In this state it is
days in earthen vessels, to ferment and purify itself, when it is fit for use.
ise be obtained from the mistletoe, the *Viburnum lantana*, young shoots
her vegetable substances.

It is sometimes adulterated with turpentine, oil, vinegar, and other matter

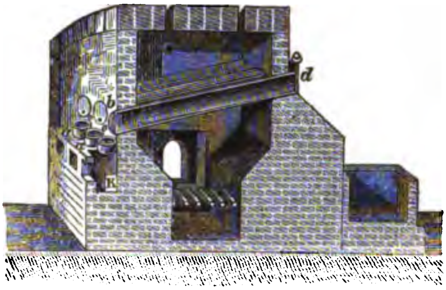
Good birdlime is of a greenish colour, and sour flavour; gluey, stringy,
cious, and in smell resembling linseed oil. By exposure to the air, it become
brittle, so that it may be powdered; but its viscidity is restored by we
reddens tincture of litmus. Exposed to a gentle heat, it liquefies slightly,
bubbles, becomes grumous, emits a smell resembling that of animal oils, gro
but recovers its properties on cooling, if not heated too much. With a great
burns, giving out a brisk flame and much smoke. The residue contains sul
chloride of potassium, carbonate of calcium, and alumina, with a small portio

BISMUTH. *Symbol* Bi. *Atomic weight* 208 (Schneider); 210 (D
The metal bismuth has long been known, but was formerly often confounde
and lead. It is principally found in the metallic state, but also occurs in
tion with sulphur, oxygen, and tellurium. In Cornwall and Cumberland it
associated with ores of cobalt, and in Siberia with lead, in the form of *ne*
bismuth-lead-ore.

For the arts it is prepared almost exclusively from native bismuth, and
source for it is Saxony, where it occurs in metallic veins in gneiss and clay-sla
panying ores of silver, copper, lead, and tin.

The process of extraction is very simple, the mineral being merely heate
vessels, so as to melt the bismuth, and thereby separate it from the gangue,
panying rock. The fusion is performed in iron tubes, laid in an inclined p
a furnace (*fig.* 100). The ore is introduced at the upper end, *d*, which is the
The other end, *b*, is cl
an iron plate having an a
through which the mel
runs into earthen pots
by a few coals placed in
K, below, so as to keep
in the melted state.
ladled out and run int
(See *Ure's Dictionary*
Manufactures, and Min

Fig. 100.



As thus prepared, th
impure, containing su
arsenic, copper, nickel,
other metals. It may
by placing it in a cru
about $\frac{1}{10}$ its weight of
keeping it melted at a temperature not too much above its point of fusion, th
being continually stirred. The nitre, at first liquid, soon solidifies, forming
impurities a slag, which collects on the surface of the metal. By repe
operation a second time, the metal is obtained pure.

Small quantities of bismuth existing in lead-, copper-, and silver-ores, oft
concentrated in the secondary products of metallurgic operations, especial
process of separating silver from lead by cupellation. The lead oxidises fa
the bismuth, so that towards the end of the operation a blackish litharge is
containing bismuth; and by reducing this mixed oxide, and again cupellin
sulting alloy of lead and bismuth, the lead is oxidised and metallic bismuth
(Jahresber. f. Chem. 1859, 711.)

To obtain chemically pure bismuth, the metal is dissolved in nitric acid;
clear solution, a large excess of water is added, which precipitates the bismut
nitrate, the other substances remaining in solution. The precipitate is well
dried, mixed with black flux, and reduced at a gentle heat in a crucible, at th
of which a regulus of pure metal is found.

Properties. — Bismuth is a metal of a greyish-white colour, with a distinc
tinge. When pure, it crystallises more readily than any other metal. It may be
in beautiful crystals by the following method. A few pounds are melted in a
and then poured into an earthen dish previously made hot. When the surf
metal has become covered with a crust, it is pierced on two opposite points w
of red hot-iron, and the liquid metal allowed to run out. On afterwards
removing the crust, the sides of the interior are found lined with beautiful
often in pyramidal cubes like the crystals of chloride of sodium. They posse
descent lustre, arising from a very thin film of oxide which has been formed
surface while still hot, and exhibits the colours of thin plates. Native bism
tallises in cubes, and combinations of the cube with the octahedron; also in
tetrahedrons, with cleavage very distinct, parallel to the faces of the octahedro

ographie). In Dana's *Mineralogy* (iii. 20), on the other hand, the crystalline stated to belong to the hexagonal system. Bismuth appears therefore to be ous. Its specific gravity is 9·83, and it exhibits the singular anomaly, that has been exposed to great pressure, its density becomes less. Pure bismuth as been exposed to a pressure of 200,000 pounds, was found to have the gravity 9·556. It melts at 264° C., and expands about $\frac{1}{32}$ in solidifying. s specific gravity is greater in the liquid than in the solid state. At a high ture, it may be distilled, and then sublimes in laminæ. It is very brittle, aminated, crystalline fracture, and is easily reduced to powder. Of all metals its in the highest degree the phenomena of diamagnetism.

ed to dry or moist air, it does not alter, but when exposed in contact with water en vessel, it becomes covered with a film of oxide of bismuth. Heated in the urns with a bluish flame, forming yellow fumes. It decomposes water at high tures only. Concentrated hydrochloric acid acts on it with difficulty; sulcid attacks it only when hot and concentrated. Nitric acid briskly attacks it cts complete solution.

uth forms three classes of compounds in which it is *di-*, *tri-*, and *pent-atomic*, vely. The tri-atomic compounds are the most stable and the most numerous, Cl^3, BiI^3, Bi^2O^3. Several di-atomic bismuth-compounds are also known, Br^2, $BiCl^2$, BiI^2, Bi^2O^2, and Bi^2S^2. The only pent-atomic bismuth-compounds obtained are the pent-oxide Bi^2O^5, together with the corresponding acid and

· E. A.

MUTH ACICULAR. Plumbo-cupreous sulphide of bismuth. See NEEDLE-

MUTH, ALLOYS OF. Bismuth unites readily with other metals, forming sible compounds.

ive *arsenide of bismuth* containing 3 per cent. of the latter metal, occurs at m, near Marienberg. It has a radiated texture like native sulphide of anti- Specific gravity 5·392. Hardness = 2 (Breithaupt). 14 pts. of bismuth th 1 pt. of arsenic yield an alloy which expands strongly in solidifying.

ony unites in all proportions with bismuth, forming brittle alloys; that which equal parts of the two metals expands considerably in solidifying.

ost remarkable alloy of bismuth is that known as "fusible metal," which of 1 pt. of *lead*, 1 of *tin*, and 2 of *bismuth*. It melts at 93·75 C. Accord-Erman, it dilates in an anomalous manner when heated. It expands regu-m 32° to 95° C., and then contracts gradually to 131°; at which point it a less bulk than it did at 32°; it then expands till it reaches 174°, and from nt its expansion is uniform. On account of this property of expanding as it hile still in the soft state, it is much used for taking impression from dies, as faintest lines are reproduced with minute accuracy. An alloy of bismuth tassium is obtained when bismuth is fused with cream of tartar, 5 pts. bismuth tartar. (For the other alloys of bismuth see the several metals.) E. A.

MUTH, BROMIDES OF. The *tri-bromide*, $Bi'''Br^3$, is formed by heating with excess of bromine. It is a steel-grey substance, like fused iodine; melts C., and boils at a dull red heat, with formation of hyacinth-red vapours. with metallic bismuth, it yields a brown crystalline mass, probably a *di-bro-* Br^2, but it has not been obtained pure. (Weber.) E. A.

MUTH, CHLORIDES OF. *Trichloride*, $Bi'''Cl^3$.—Bismuth and chlorine combine, with evolution of heat and light if the metal be finely divided. On bismuth in a tubulated retort, in a current of chlorine, trichloride of bismuth s a white easily fusible substance. It readily attracts moisture from the air, g converted into a crystallised hydrate. The same substance is produced smuth is dissolved in aqua-regia, and the excess of acid evaporated. Chloride uth dissolves in water containing hydrochloric acid; by pure water it is de-d into hydrochloric acid, which dissolves a portion of the chloride, and a pre- consisting of oxychloride of bismuth:

$$BiCl^3 + H^2O = BiClO + 2HCl.$$

solution of nitrate of bismuth is poured into solution of common salt, a white ine precipitate is formed, which is also *oxychloride* of bismuth, $BiCl^3.Bi^2O^3$ O. It is used for paint, and is known as "pearl white." Chloride of bismuth ystallisable double salts with the chlorides of potassium, of sodium, and of am- They are isomorphous with, and analogous in composition to, the correspond-ble chlorides of antimony.

LORIDE OF BISMUTH, $BiCl^2$, is produced by heating the trichloride with metal-uth, also by the direct action of chlorine upon bismuth, provided the action

be moderated by confining the current of chlorine to the upper part of the retort. Partial reduction of the trichloride is likewise effected by phosphorus, zinc, tin, mercury, and silver. The dichloride is a brown crystalline mass easily fusible and easily decomposed by water or by a strong solution of sal-ammoniac. At a high temperature, it is resolved into metallic bismuth and trichloride. (R. Weber, Pogg. Ann. cvii. 596.)
E. A.

BISMUTH CUPREOUS. See TANNENITE and WITTICHITE.

BISMUTH, DETECTION AND ESTIMATION OF. *Blowpipe reactions.*—All bismuth-salts, and likewise the sulphide, are easily reduced by mixing them with carbonate of sodium, and heating the mixture on charcoal in the inner blowpipe flame. A brittle bead of metallic bismuth is thereby produced, and a lemon-yellow oxide, similar to lead-oxide, but darker, is deposited on the charcoal around. This deposit disappears when heated in the reducing flame, without colouring the outer flame, a character by which it is distinguished from lead. Oxide of bismuth is easily reduced on charcoal without addition of soda.

In *borax* on platinum-wire, bismuth-oxide dissolves to a clear glass, yellow while hot, and colourless when cold, if not supersaturated; in the latter case, yellowish-red while hot, yellow when cold. In the inner flame on charcoal, the borax-glass becomes grey and turbid, afterwards perfectly clear. The addition of *tin* makes it grey at first, but after complete reduction, colourless and transparent.

In *phosphorus-salt* on platinum-wire, a small quantity of bismuth-oxide forms a colourless glass; with a large quantity, the glass is yellow while hot, colourless, or sometimes enamel-white, on cooling. On charcoal, especially with addition of tin, the glass is transparent and colourless while hot, but becomes blackish-grey and opaque on cooling. (Berzelius and Plattner.)

Liquid Reactions.—The salts of bismuth are mostly colourless. They have an acid reaction, and their solutions when diluted with *water*, become milky, and yield a white precipitate, consisting of an insoluble basic salt, while an acid salt remains in solution. This reaction is best seen with the chloride, as the oxychloride formed is almost absolutely insoluble. *Iron*, *copper*, *lead*, and *tin*, precipitate bismuth from its solutions in the metallic state. *Sulphydric acid* and *sulphide of ammonium* throw down a brown-black precipitate of trisulphide of bismuth, insoluble in excess of sulphide of ammonium. *Caustic alkalis* and their *carbonates*, *phosphates*, *oxalates*, and *tartrates*, throw down white precipitates, insoluble in excess of caustic potash or soda. *Chromate of potassium* throws down a yellow precipitate of chromate of bismuth, insoluble in caustic potash. Soluble *sulphates* produce no precipitate. This last character, together with the insolubility of the precipitated chromate, hydrate, &c., in caustic potash, distinguishes bismuth from lead. From antimony, which resembles it in the decomposition of its salts by water, it is distinguished by its behaviour with sulphydric acid, and by the insolublility of the basic salts thrown down by water, in tartaric acid.

Quantitative Estimation.—The best reagent for precipitating bismuth from most of its solutions, is carbonate of ammonium, which, when added in excess, throws down the bismuth completely, provided the liquid be left to stand for some hours in a warm place. The precipitate, after being washed and dried, must be separated from the filter as completely as possible, the filter separately burned, and the precipitate ignited in a porcelain crucible; a platinum crucible would be attacked by it on ignition. It consists of trioxide of bismuth, Bi^2O^3, containing 89·66 per cent. of the metal.

If the solution contains hydrochloric acid, the bismuth cannot be estimated by precipitation with carbonate of ammonium or any other alkali, because the precipitate so formed would contain oxychloride of bismuth, and on igniting it, part of the bismuth would be volatilised as chloride. In this case, therefore, the bismuth must be precipitated by sulphydric acid, the sulphide of bismuth oxidised and dissolved by nitric acid, and the diluted solution precipitated by carbonate of ammonium.

Atomic Weight of Bismuth.—The first approximately correct determinations of the atomic weight of bismuth were made in 1815 by Lagerjhelm (Ann. Ch. xciv. 161), who, from the proportion of bismuth in the sulphide Bi^2S^3, in the oxide Bi^2O^3, and the sulphate $Bi^2(SO^4)^3$, estimated the atomic weight at 214·8, 212·8, and 212·8, respectively. L. Gmelin (Handbook, iv. 428) found that these numbers were too high, and that the oxide Bi^2O^3 contained at least 10·33 per cent. oxygen; whence

$$Bi^2 : O^3 = 89{\cdot}67 : 10{\cdot}33;\ \text{and } Bi = \frac{89{\cdot}67 \times 48}{2 \times 10{\cdot}33} = 208{\cdot}2 \text{ at most.}$$

This result was confirmed by Schneider in 1851 (Pogg. Ann. lxxxii. 303). Pure bismuth was oxidised by nitric acid in a flask (the small portions of metal carried off vapours, being collected and allowed for), the solution evaporated, and the gently ignited. Eight experiments thus made, showed that 100 pts. of tri- f bismuth, Bi^2O^3, contain from 10·318 to 10·366 pts. oxygen; mean = 10·345:

$$Bi = \frac{89·655}{20·690} \times 48 = 208·0.$$

ly, **Dumas** (Ann. Ch. Pharm. cxiii. 38), has determined the atomic weight of h by decomposing the trichloride $BiCl^3$ (prepared by passing chlorine gas over h, and distilling till the product passed over is colourless), with excess of car- of sodium, and estimating the chlorine in the filtrate by means of a standard olution. Three experiments, with the purest portion of the distillate, gave mbers 209·88, 210·08, and 210·27. Dumas considers 210 to be the correct r.

aration of Bismuth from other Elements.—From the *non-metallic* ele- excepting *selenium*), and from the *alkali-metals*, bismuth is separated by carbo- ammonium; from the *earth-metals*, and from *iron*, *cobalt*, *nickel*, and the netals of the second group (p. 217), it is separated by sulphydric acid; from enic, *antimony*, and *tellurium*, by sulphide of ammonium; and from *copper* and *m*, by ammonia. The separation of bismuth from *cadmium* may also be effected nide of potassium, which dissolves the latter as cyanide of cadmium and potas- and precipitates the bismuth. The precipitated bismuth, however, always s potash, and must therefore be dissolved in nitric acid, and precipitated by ate of ammonium. Another mode of separating these two metals, given by (J. pr. Chem. lxvii. 464), is to heat the solution containing them with acid chro- f potassium, which throws down the bismuth as $Bi^2O^3.2CrO^3$, and retains the m in solution.

separation of bismuth from *lead* cannot be effected by caustic potash, although soluble in that reagent, and bismuth insoluble; for, when the metals are mixed tion, the oxide of lead precipitated by potash always carries some bismuth- lown with it. The two metals may, however, be separated: — 1. By sulphuric The acid is to be added in excess, the solution evaporated till the excess of ric acid begins to volatilise, and then diluted with water, whereupon the sulphate l is left undissolved, while the sulphate of bismuth dissolves completely, pro- sufficient excess of sulphuric acid is present. The sulphate of lead is then ed on a filter, and washed with water containing sulphuric acid, and the bismuth ipitated from the filtrate by carbonate of ammonium, after the excess of acid en partly neutralised by ammonia. This method is not quite exact, because te of lead is not perfectly insoluble in acid liquids; sulphuric acid, however, es less of it than any other acid.—2. Another mode of separating lead from h, is to dissolve the two metals or their oxides in nitric acid diluted with a very quantity of water, then add hydrochloric acid in sufficient quantity to convert etals into chlorides, and afterwards a considerable quantity of strong alcohol with a little ether. The chloride of bismuth is thereby held in solution, while loride of lead is completely precipitated, and may be collected on a weighed nd washed with alcohol containing ether. Lastly, the alcoholic solution of e of bismuth is diluted with water, the alcohol evaporated, and the bismuth tated by sulphuretted hydrogen. This method becomes more exact as the alcohol stronger. — 3. Ullgren separates bismuth from lead by precipitating the two as carbonates, redissolving them in acetic acid, and immersing in the liquid a d strip of clean sheet-lead, which must be completely covered by the liquid; ssel is then closed and left to itself for several hours. The bismuth is thereby tated as a metallic powder. It is rinsed off the surface of the lead, which is ried and weighed, and the precipitated bismuth is collected, dissolved in nitric nd precipitated by carbonate of ammonium, or estimated by simply evaporating ution and igniting the residue. The lead in the solution is also precipitated by ate of ammonium, and the carbonate of lead is converted into oxide by ignition, ighed, a deduction being made of the quantity of lead-oxide corresponding to the hich has been dissolved.—4. When lead and bismuth are mixed in the metallic they may be separated by passing chlorine over the heated alloy, chloride of h then volatilising, while chloride of lead remains. Great care is, however, d in regulating the heat, as too high a temperature would volatilise some of the e of lead, and if the heat be too low, a portion of the chloride of bismuth will .

the separation of bismuth from *mercury*, *silver*, *gold*, *platinum*, and its allied , see the several metals.

uation of Bismuth-ores.—Ores containing only metallic bismuth, are d by heating them in a crucible perforated at the bottom, and standing over a

receiver, into which the melted metal runs. The process is not quite exact, as
quantity of the metal remains mixed with the ore; but it is sufficient for a c
the results of the smelting on the large scale. If the ore likewise contains sul
bismuth, it is ignited with two or three times its weight of black flux, sometim
addition of metallic iron, also of borax, if much earthy matter is present. If
also contains other metals, which are reduced together with the bismuth, the
button must be dissolved, and the several metals separated by analysis in
way, as above described. (Kerl, Hüttenkunde, ii. 355.)

BISMUTH, FLUORIDE OF. Soluble in water and deposited as a white
when the aqueous solution is evaporated. (Berzelius.)

BISMUTH, IODIDE OF. BiI^3.—Obtained by mixing 1 at. of trisul
bismuth (which has been prepared by precipitation) with 3 at. of iodine, an
heating the mixture in a capacious loosely covered glass globe, on the sides o
the compound condenses. The iodine simply takes the place of the sulphur (S
der.) It is likewise produced by throwing iodine in small portions into a
which bismuth is strongly heated, and distilling out of contact with the air (W
It forms large brilliant grey hexagonal tables, which, according to N
(Compt. rend. l. 872) are isomorphous with the tri-iodides of arsenic and a
Metallic bismuth decomposes it in the same manner as the tribromide. (W

An *oxyiodide* of bismuth, BiIO, is formed when the tri-iodide is heated for so
in a crucible, and collects below the crystallised iodide thus obtained, in a
copper-coloured rhombic laminæ. In a close vessel, it may be partially vo
without alteration, but when strongly heated in contact with the air, it is co
into oxide. It is not decomposed by water or by alkaline solutions; hydr
acid dissolves it without alteration; nitric acid decomposes it, with separation o
(Schneider, J. pr. Chem. lxxix. 424.)

A *sulphiodide*, BiIS, is obtained by adding to melted iodide of bismuth, a
sulphur as it is capable of dissolving; it is likewise produced in the preparatio
tri-iodide by Schneider's method, and collects at the bottom of the vessel.
with a small quantity of the iodide, in small, shining, steel-grey needles. It
to have the same form as the trisulphide. (Schneider, J. pr. Chem. lxxix. 4

BISMUTH, OXIDES OF. Bismuth forms two definite compounds with
Bismuthous oxide or *trioxide of bismuth*, Bi^2O^3, and *bismuthic oxide* or *an*
Bi^2O^5. An intermediate oxide, Bi^2O^4, is known, but it may be regarded as a co
of the other two—a *bismuthate of bismuth*, $Bi^2O^3 . Bi^2O^5$. A dioxide, Bi^2O^2, app
to exist; it is formed when a solution of a bismuth-salt is treated with proto
of tin. A corresponding sulphide is known.

BISMUTHOUS OXIDE, or TRIOXIDE OF BISMUTH, Bi^2O^3, is formed when the
roasted in air, but is best obtained by gently igniting the subnitrate. It is a pale
powder, which melts at a red heat, and solidifies on cooling to a glass having a
yellow tint. It occurs native, as *bismuth-ochre*, associated with iron and som
impurities (Bi^2O^3 86·4 per cent.; Fe^4O^3 5·1; CO^2 4·1; water 3·4), at Schnee
Saxony, at Joachimsthal in Bohemia, and with native gold at Beresof in
(Dana, ii. 141.)

The hydrated oxide of bismuth, $BiHO^2$. or $Bi^2O^3H^2O$, is obtained as a white
tate when a solution of subnitrate of bismuth is decomposed by an alkali.
hydrate be boiled with potash, it loses water, and is changed into a yellow cry
powder which is the anhydrous oxide.

The hydrate is occasionally used in analysis for converting into oxides
metallic sulphides soluble in alkalis. For this purpose, the alkaline solutions ar
with the hydrated oxide.

Both the hydrate and the anhydrous oxide dissolve in the stronger acids, f
the normal bismuth salts, which have the composition $Bi'''A^3$, the symbol A
ing an acid radicle, *e. g.*:

$$BiCl^3;\ Bi(NO^3)^3 = \left.\begin{matrix}(NO^2)^3\\ Bi'''\end{matrix}\right\}O^3;\ Bi^2(SO^4)^3 = \left.\begin{matrix}(SO^2)''^3\\ (Bi''')^2\end{matrix}\right\}O^6, \&c.$$

Many of these salts crystallise well, but cannot exist in solution unless an ex
acid is present. On diluting the solutions with water, a basic salt is precipitat
an acid salt remains in solution.

BISMUTHIC OXIDE or ANHYDRIDE, Bi^2O^5;—in combination: BISMUTHIC ACID.-
pared by passing chlorine through a concentrated solution of potash which c
hydrated trioxide of bismuth in suspension. A blood-red substance then sep
which is a mixture of hydrated bismuthic acid, and trioxide of bismuth. This is

te nitric acid, which dissolves the oxide, but, in the cold, does not attack the

thic oxide is a bright red powder, which loses part of its oxygen at a tempera-
e above 100° C. and becomes converted into the intermediate oxide, Bi^2O^4,
te of bismuth. Acids also decompose it, reducing it to the state of bismuthous
hich then combines with the acid.

ismuthates are little known, and of no importance; according to Arppe,
c acid forms with potash, a salt which is an *acid bismuthate of potassium:*
$= BiKO^3.BiHO^3$. E. A.

MUTH, OXYCHLORIDE OF. (p. 591.)

MUTH OXYGEN-SALTS OF. See the several acids.

MUTH, PHOSPHIDE OF. Melted bismuth takes up a small quantity of
rus, being thereby rendered more brittle and less laminar. Phosphoretted
gas throws down from solution of nitrate of bismuth a black phosphide of
l, which gives off all its phosphorus by distillation. (Berzelius.)

MUTH, SELENIDE OF. Bismuth and selenium unite when heated toge-
h faint evolution of light and heat, and form a silver-white mass, having a
e fracture, and fusing at a red heat: the fused mass has a specular surface.
ius.)

MUTH, SULPHIDES OF. Bismuth readily unites with *sulphur.* When
substances in fine powder are fused together, they combine, with disengage-
heat. Two distinct compounds are known.

PHIDE OF BISMUTH, $Bi''S$.—According to Wertheim, it is obtained crystallised
ng together bismuth and trisulphide of bismuth in equivalent quantities. The
is then allowed to cool slowly, on which the sulphide crystallises from the
etal, which may be poured off from the crystals. More recently it has been
at these crystals, although giving by analysis numbers corresponding to BiS,
y a compound of trisulphide of bismuth with metallic bismuth. According to
r, disulphide of bismuth may be prepared in the moist way, by mixing an
solution of bismuthous oxide with an alkaline solution of stannous oxide, and
ting with sulphuretted hydrogen. The tin remains dissolved, and a black pre-
s formed, which, when washed and dried in the water-bath, is found to have the
ion $BiS.H^2O$. It is a black lustreless powder, which, under the burnisher, takes
of black laminæ.

LPHIDE OF BISMUTH, Bi^2S^3, occurs native as bismuth-glance, or *bismuthine*, in
and and Cornwall, also in Saxony, at Bastnäs in Sweden, and according to
at Haddam in Connecticut, associated with chrysoberyl. It crystallises in aci-
sms of the trimetric system, isomorphous with native sulphide of antimony.
$\breve{P}\infty . \infty P\infty . \infty P3 . oP$. Inclination of $\infty P : \infty P = 91° 30'$. Cleavage
parallel to oP and $\infty \breve{P}\infty$; less perfect parallel to $\infty \bar{P}\infty$. It occurs also
with foliated or fibrous structure. Specific gravity 6·4 to 6·55. Hardness
2·5. Opaque, with metallic lustre, lead-grey colour and streak. Sectile.
ii. 33.)

me compound is prepared in the dry way, by fusing pulverised bismuth with
l of its weight of sulphur, and removing the excess of sulphur by a second
A laminated mass is thus obtained, composed of crystals having the same form
ative sulphide. According to Marx, it expands to the amount of one-fourth its
n solidifying. The trisulphide is also obtained as a brown-black precipitate,
lphydric acid gas is passed into the solution of a bismuth-salt. E. A.

MUTH, SULPHOCHLORIDE OF. BiSCl, or $BiCl^3.Bi^2S^3$.—This com-
best obtained by gradually adding pulverised trisulphide of bismuth to
mmonio-bismuthous chloride ($2NH^4Cl.BiCl^3$), and washing the resulting mass
er acidulated with hydrochloric acid. It is also formed by heating the same
hloride with sulphur, or in sulphydric acid gas. It forms small, metallic-
blue-grey crystalline needles, which yield a red powder. Heated in carbonic
it gives off chloride of bismuth and leaves the sulphide; heated in hydrogen,
ff hydrochloric and sulphydric acids, and leaves bismuth. It is decomposed
hydrochloric and strong nitric acid; also by alkalis, which remove the chlo-
leave an oxysulphide. (R. Schneider, Pogg. Ann. xciii. 464.)

MUTH, TELLURIC. Bi^2STe. See TELLURIUM.

MUTH, TELLURIDE OF. The two metals unite in all proportions by

MUTH-BLENDE. Native silicate of bismuth. See SILICATES.

MUTH-GLANCE, or **BISMUTHINE.** Native trisulphide of bismuth
e).

BISMUTH-NICKEL. *Grünauite. Saynite.*—A sulphide of bismuth and n
found, together with quartz and copper pyrites, at Grünau in Sayn Altenki
crystallised in regular octahedrons, sometimes perfect, sometimes having the su
more or less replaced by faces of the cube. Cleavage octahedral. Specific g
5·13. Hardness 4·5. Colour, light steel-grey to silver-white, often yellowish or g
from tarnish. Its composition in 100 parts is given by the following analyses:

S	Bi	Ni	Fe	Co	Cu	Pb	
38·46	14·11	40·65	3·48	0·28	1·68	1·58	Kobell.
31·99	10·49	22·03	5·55	11·24	11·59	7·11	Schnabe
33·10	10·41	22·78	6·06	11·73	11·56	4·36	"

Before the blowpipe it melts to a grey, brittle, magnetic globule, colouring the
coal greenish-yellow. Dissolves in nitric acid, excepting the sulphur. (Dana,

BISMUTH-OCHRE. Native trioxide of bismuth (p. 594).

BISMUTH-RADICLES, ORGANIC. The only compounds of this cl
yet obtained, are the *Bismuthides of Ethyl*, viz. *Bistriethyl*, discovered by L
and Schweizer (Ann. Ch. Pharm. lxxv. 355), and further examined by Breed
lxxxii. 106), and *Bisethyl*, discovered by Dünhaupt in 1854 (*ibid.* xcii. 372).

BISETHYL. C^2H^5Bi.—The *chloride* of this radicle, $C^2H^5BiCl^2$ (?) is obtained, to
with a precipitate of chloride of hydrargethyl, by the action of bistriethyl on ch
of mercury (p. 596). The chloride of bisethyl remains in solution and may be ob
by spontaneous evaporation in crystals, which however do not dissolve complet
water, but leave a white powder. On adding iodide of potassium to the aqueous
tion, then diluting with water till turbidity is produced, boiling till the soluti
comes clear, and leaving it to cool, *iodide of bisethyl* separates in yellow six
laminæ, which appear to have the composition $C^2H^5BiI^2$. A solution of this com
in hydrated alcohol treated with ammonia, forms a yellowish-white precipitate o
hydrated oxide, which, after drying in vacuo, ignites spontaneously in the air, giv
a dense yellow vapour. The oxide appears also to be formed by the sponta
oxidation of bistriethyl, 2 atoms of ethyl being eliminated. *Sulphide of bis*
formed by treating the iodide with sulphydric acid; and the nitrate and su
by acting on the iodide with the corresponding silver-salts. (Dünhaupt.)

BISTRIETHYL, or TRIETHYL-BISMUTHINE. $(C^2H^5)^3Bi$. *Bismethyl.*—Formed b
action of iodide of ethyl on bismuthide of potassium.

Preparation.—Bismuthide of potassium, finely pounded, and without admixt
sand, is introduced into a small flask; iodide of ethyl added in excess; the flask c
and immediately connected with a long narrow distillation-tube passing into a re
surrounded with ice, all these manipulations being performed as quickly as po
In a few minutes, the action begins, the mixture becomes heated, and the exc
iodide of ethyl distils over. Water free from air is then introduced into the
which is immediately closed and heated in the water-bath, till the mass become
and the iodide of potassium is dissolved. The same operations are repeated w
considerable number of flasks; the disintegrated contents transferred as quick
possible into a large flask filled with carbonic anhydride; shaken up several times
a large quantity of ether; the ethereal solution mixed with the de-aërated water
the ether completely distilled off in the water-bath. The bistriethyl remains
bottom of the water, and is purified by distilling it with water (it cannot be di
alone, without decomposition), shaking it up with a small quantity of dilute nitri
to free it from oxide, and drying over chloride of calcium. During all these opera
the air must be carefully excluded (Breed). 3 lbs. of bismuthide of potassium
1 lb. of iodide of ethyl, yield 4 or 5 oz. of pure bistriethyl. (Dünhaupt.)

Properties.—Transparent, very mobile liquid, sometimes colourless, but often sli
tinged with yellow. Has an unpleasant odour like that of stibtriethyl, and its va
when inhaled, even in small quantity, produces a very disagreeable burning sens
on the tip of the tongue (Breed). Insoluble in water, sparingly soluble in e
readily in absolute alcohol.

Decompositions.—1. Bistriethyl heated in a retort, begins to boil at about 5
giving off a gas free from bismuth, which burns with a clear flame, while metalli
muth separates out in the retort. If the heat be continued, the thermometer
above 160° C., and continues to rise till a sudden and violent explosion takes p
which shatters the apparatus (Breed). The dilute ethereal solution is also decomp
when left to evaporate in the air, leaving a white residue of hydrated oxide of bis
(Dünhaupt).—2. Bistriethyl exposed to the air, gives off thick yellow vapours
takes fire with slight explosion, diffusing a dense yellow smoke of bismuth-oxide;
effect is best shown by moistening a piece of filtering paper with the liquid and
posing it to the air.—3. Fuming nitric acid decomposes bistriethyl, with explosion

bustion.—4. Bistriethyl burns in chlorine gas with separation of charcoal,
fire in contact with bromine. In general, its reactions resemble those of
yl (Breed).—5. Bistriethyl added to solutions of metallic salts (*e.g.* to
silver or corrosive sublimate), does not simply throw down the oxide, but is
omposed. On adding an alcoholic solution of bistriethyl to a not too dilute
f protochloride of mercury, the former being poured slowly and with constant
nto the latter, a very large precipitate of mercurous chloride is immediately
chloride of bismuth and hydrochloric ether being doubtless formed at the
. But if the process be reversed, and a hot dilute alcoholic solution of cor-
limate be poured in a thin stream and with constant stirring into a dilute
solution of bistriethyl to which a few drops of hydrochloric acid have been
prevent separation of oxide of bismuth, no precipitate is formed at first; but
e time, a bulky precipitate appears, which however is again completely dis-
the liquid be heated. The reaction is terminated when a drop of the liquid
produces a white precipitate in a solution of corrosive sublimate; by a little
ay be arranged that neither liquid shall predominate. If the liquid be then
the water-bath till it becomes perfectly clear, separated, if necessary, from a
ntity of metallic mercury by decantation, and then left to cool, light, crys-
very, iridescent laminæ separate out and gradually fill the whole fluid. These
onsist of *chloride of hydrargethyl*, $C^2H^5Hg''Cl$; the solution from which they
ited contains *chloride of bisethyl*, $C^2H^5BiCl^2$ (Dünhaupt):

$$(C^2H^5)^3Bi + 2Hg''Cl^2 = 2C^2H^5Hg''Cl + C^2H^5BiCl^2.$$

ations.—Bistriethyl combines with *Bromine*, *Iodine*, *Sulphur*, &c.; but the
ls are less stable than those of stibtriethyl.

le of Bistriethyl appears to be formed when bromine is added to an alcoholic
f bistriethyl; but the solution deposits bismuth when evaporated.

of Bistriethyl.—When iodine is added to an alcoholic solution of bistriethyl,
olved, the colour of the iodine disappears, and iodide of bistriethyl is formed.
pound is less stable than iodide of stibtriethyl; when its alcoholic solution is
elf for a while, iodide of bismuth separates out. (Breed.)

ide having the composition $C^6H^{15}Bi^2I^5$, or $(C^2H^5)^3BiI^2.Bi^2I^3$, is obtained by
dine to a tolerably strong alcoholic solution of bistriethyl, till its colour [no
disappears, filtering from the precipitate, and adding to the filtrate a large
of water at 40° C. A small quantity of a ruby-coloured liquid separates; and
tery liquid be poured off from this, a large quantity of beautiful red needle-
ystals are formed as it cools; these must be immediately collected and dried
The same compound is formed when bistriethyl is left for a considerable
ontact with dilute nitric acid and then mixed with iodide of potassium. It is
soluble in water, but dissolves pretty readily in alcohol and ether; the solu-
e a pale yellow colour. The compound heated on platinum foil gives off
yellow vapour which takes fire on coming in contact with flame. (Dün-

r iodine-compound, having the formula $(C^2H^5)^4Bi.2C^2H^5I$, is contained in the
ntioned ruby-coloured liquid; but it is very instable. (Dünhaupt.)

de of Bistriethyl, has not been obtained in the separate state. Bistriethyl
s been long exposed to the air under water, gives with sulphuretted hydro-
a yellow, then a brown precipitate, consisting of $(C^2H^5)^2BiS.Bi^2S^3$. (Dün-

UTH-SILVER. A mineral sometimes occurring in acicular or capillary
ations, but more generally amorphous, as at Schapbach in Baden; it is found
e cupreous shale of Mansfeld, Thuringia. It is soft and sectile, opaque, with
ustre and tin-white or greyish colour, subject to tarnish; fracture uneven.
according to Klaproth's analysis, 27 per cent. bismuth, 33 lead, 15 silver,
0·9 copper, and 16·3 sulphur. A *bismuth-silver* from the mine of San Antonio
ipo, Chili, was found by Domeyko to contain 60·1 per cent. silver, 10·1 bis-
copper, 2·8 arsenic, and 19·2 gangue. It occurs disseminated, and has one
imperfect cleavages, and is probably either monometric or rhombohedral.
i. 16.)

UTITE. Native carbonate of bismuth. See CARBONATES.

A-BOL. A gum resin from Arabia, resembling myrrh. (Vaughan,
. Trans. xii. 227.)

RE. A brown pigment, consisting of the finer parts of wood-soot, separated
grosser by washing. The soot of beech-wood is said to yield the best bistre.
s Dictionary of Arts, Manufactures, and Mines, i. 307.)

ER-ALMOND OIL. A peculiar volatile oil obtained by distilling bitter-

almonds with water. It was discovered by Martrès in 1803; Stange showed tha
crystallised acid which is produced from it is benzoic acid; Robiquet, and Liebig
Wöhler explained its formation; and Liebig and Wöhler (1832, Ann. Ch. Ph
xxii. 1) first fully examined it. It is also obtained from the amygdaliferous par
most *Pomeæ* and *Amygdaleæ;* from the leaves of the cherry-laurel (*Cerasus l*
cerasus), and of *Cerasus padus*, from peach and cherry-kernels, &c. It is po
that many of these oils are not identical, but isomeric, with bitter-almond oil, an
it is owing to their presence that different specimens of the commercial oil yield
the same reagent such different results. The chief constituent of the oil is hydri
benzoyl, always accompanied by hydrocyanic acid and other compounds (see BEN
HYDRIDE OF). The oil does not exist ready-formed in bitter-almonds, but is pro
by the action of water and a peculiar ferment, *emulsin* or *synaptase*, upon
amygdalin contained in the almonds, which is thereby converted into hydride of
zoyl, hydrocyanic acid, and glucose:

$$\underset{\text{Amygdalin.}}{C^{20}H^{27}NO^{11}} + 2H^2O = \underset{\substack{\text{Hydride}\\\text{of benzoyl.}}}{C^7H^6O} + CNH + \underset{\text{Glucose.}}{2C^6H^{12}O^6}.$$

The oil is thus prepared: Bitter-almonds are crushed, and freed from fixed o
cold pressing, then stirred up to a thin paste with 4—6 pts. cold or lukewarm w
and the mixture allowed to stand for twenty-four hours before distillation. I
tilled over the open fire, it is very apt to froth over, unless it is stirred contin
for this reason it is best distilled with vapour of water. This may be done by cov
the bottom of the still with a thick layer of coarse sand saturated with water
pouring the almond-paste upon it. The frothing may also be avoided by rem
most of the solid matter before distilling. The first portion of the distillate is rich
oil, and in hydrocyanic acid also, and is therefore clear; the latter portions, conta
less hydrocyanic acid, are milky. The distillation is continued as long as the
which comes over smells of bitter-almonds; the oil in the receiver is then sepa
from the water, which, as it contains a good deal of oil in solution, is again dis
when the oil passes over with the first portions of the water. The addition of ch
of sodium facilitates the separation of the oil. 1000 pts. almonds do not yield
than 7 or 8 pts. oil.

Bitter-almond oil is colourless when freshly prepared, but soon becomes yello
has a peculiar strong aromatic smell, besides that of prussic acid, and a burning
is heavier than water; boils at about 180° C., and burns with a smoky flame. I
sonous action is entirely owing to the presence of prussic acid. (For methods o
fying the oil, see BENZOYL, HYDRIDE OF.)

Bitter-almond oil was formerly much used in perfumery, but it is now replac
great measure by nitrobenzene (*essence de Mirbane*). Being an expensive articl
very liable to adulteration, usually with alcohol (which, if added in moderation
not materially affect its smell), light ethereal oils, or nitrobenzene. Light oils,
smell is masked by that of hydride of benzoyl, may be detected by allowing the
to oxidise into benzoic acid by exposure to the air, when the smell of the form
comes evident, or by their effect on the specific gravity of the oil, a method
applies to alcohol also. Alcohol may also be detected by agitating the oil with
its volume of nitric acid of specific gravity 1·42; with unadulterated oil, no imm
action is produced; but, if 8—10 per cent. alcohol be present, red fumes are giv
with effervescence. By using acid of 1·5 specific gravity, as little as 3—4 per
alcohol may be detected (Redwood). A good reagent for detecting adulterati
a strong solution of an acid sulphite of alkali-metal, which dissolves the pure oil en
but leaves behind all impurities which are not of the nature of aldehydes.

Owing principally to the presence of hydrocyanic acid, bitter-almond oil be
with several reagents differently from hydride of benzoyl. By *heat* and by oxi
agents generally, *e.g.* by nitric acid, it is acted on in the same manner as hydr
benzoyl. With *sulphuric acid*, it yields stilbous acid, and (perhaps) benzoate o
dride of benzoyl. A mixture of Nordhausen sulphuric acid with bitter-almo
yields, on addition of water, a crystalline body, which presents the properties of
delic acid. Dry *chlorine* acts upon it as upon hydride of benzoyl; with moist ch
it forms stilbesic acid and *benzoate of hydride of benzoyl*. To this latter com
which is frequently regarded as identical with stilbous acid, Liebig assigns th
mula $C^{21}H^{18}O^4 = 2C^7H^6O + C^7H^6O^2$. Bitter-almond oil saturated with moist ch
solidifies finally to a crystalline mass, which, when washed with cold ether, leav
compound as a crystalline powder. It is insoluble in water, slightly soluble i
ether, abundantly in alcohol. When heated, it melts and volatilises undecom
Heated with alcoholic potash, it yields potassic benzoate. With *hydrochloric* a
yields either hydrocyanate of hydride of benzoyl or mandelic acid. With *chl*

it yields stilbous acid. With *sulphide of ammonium*, it yields hydride of oyl, hydride of sulphozobenzoyl, and sulphydrate of azobenzoyl. With *bi- of carbon* and *ammonia*, it yields sulphocyanobenzylene. With *cyanide of n*, it yields sometimes benzoin, sometimes benzamide. Solid *potash* converts enzoic acid; aqueous or alcoholic potash (especially the latter) into benzoin. *monia*, it yields very various products, according to circumstances; these are azo- , azobenzoidin, azobenzoyl, benzamil, benzhydramide, benzoylazotide, diben- e, hydrobenzamide, stilbazide. Most of these compounds were discovered by and many are very imperfectly known. *Baryta-* or *lime-water* converts it zoin. F. T. C.

TER-ALMOND WATER. A pharmaceutical preparation, employed in , consisting of a solution of bitter-almond oil in water. It is prepared in the nner as bitter-almond oil; but, since the water must be of a known strength, tity of almonds and water to be employed and of distillate to be collected is the pharmacopœia. These quantities vary in different pharmacopœias: in the , 2 lbs. almonds are pressed and macerated with 10 lbs. water, 4 ozs. alcohol nd 2 lbs. of distillate collected. The Parisian pharmacopœia collects 2 lbs. n 3 lbs. of distillate for each pound of almonds. The addition of alcohol does to have any advantage. Heat must be carefully avoided in the pressure and on of the almonds. Bitter-almond water is generally a more or less milky liquid, and tasting strongly of crude bitter-almond oil; it decomposes by exposure to the must therefore be kept in stoppered bottles completely full. Its strength is very , however closely the pharmacopœia directions are adhered to. It is usually y the amount of prussic acid which it contains, which may be readily deter- Liebig's volumetric method (see HYDROCYANIC ACID, under CYANOGEN); the pharmacopœia requires it to contain 0·14 per cent. prussic acid. *Laurel-water*, from laurel leaves, and *cherry-water* from wild cherries, contain the same nts as bitter-almond water. The latter may be distinguished from laurel- becoming milky immediately on addition of ammonia, an effect which is uced on laurel-water till after some time; or, according to Lepage, by chloride which gives with both waters a yellow colour, which, in bitter-almond water, rs in eight hours, while in laurel-water it remains for twenty-four hours. (J. . xxiv. 365.) F. T. C.

TER PRINCIPLE. Many vegetable substances yield bitter extracts, which nerly supposed to contain a common constituent, called *Principium amarum*. act investigation having shown, however, that many of these vegetable bitters nite chemical compounds of very various composition, *e.g.* picric acid and the e alkaloids, the term bitter principle is now restricted to the brown amor- itter extractive matter obtained from many plants by boiling with water, ing the extract to dryness, exhausting with hydrated alcohol, evaporating, and the residue with absolute alcohol, which dissolves resins, &c., and leaves the bstance undissolved. The products thus obtained, are not, generally speaking, e constitution. From some plants, however, more definite bitter principles ned, *e. g. asbinthin* from wormwood, *aloin* from aloes, &c.

TERN. The mother-water which remains after the crystallisation of common sea-water or the water of salt-springs. It contains a considerable quantity te and chloride of magnesium, to which its bitterness is owing, also more or ine and iodine.

TER SPAR or **RHOMBSPAR.** *Brown-spar. Pearl-spar. Talc-spar.* . *Chaux carbonatée magnésifère.*—This mineral crystallises in rhombohedrons, re formerly confounded with those of calcspar, but differ in the angles, the form being an acute rhombohedron of 106° 18′, and 73° 42′ (mean). The re generally rhombohedrons R, with more acute or more obtuse rhombohedron nation, the base 0R and the hexagonal prisms ∞R often occurring. The generally has its faces curved like a saddle; $\frac{1}{4}$ R is more generally lenticular. parallel to R. Fracture conchoïdal, uneven, splintery, and earthy. Colour eyish, or yellow, with a somewhat pearly lustre. Rarely transparent, but ex- rious degrees of translucence down to complete opacity. Hardness 3·5 to 4·5. gravity 2·8 to 3·0. Its formula is $(Ca; Mg)''CO^3$, the calcium and magnesium one another in any proportion, so that it presents all varieties of composition, t of calcspar to that of magnesite. Iron (*ferrosum*) and manganese (*manga-* lso occur, replacing the other metals in subordinate proportions. In the state r, it dissolves readily in warm hydrochloric acid, but in lumps the acid scarcely n it. Before the blowpipe, it becomes caustic, but does not melt. It is mbedded in serpentine, chlorite, or steatite, and is found in the Tyrol, Salz-

burg, and Dauphiny; in Scotland, on the borders of Loch Lomond, in chlorite
and near Newton Stewart in Galloway, also in the Isle of Man. It bears the
relation to dolomite, or massive magnesian limestone, that calcspar bears to co
limestone.

BITTERSWEET. *Stipites Dulcamaræ.* The stems of *Solanum Dulcamara*

BITUMEN. This term includes a considerable number of inflammable m
substances, mainly consisting of hydrocarbons. They are of various consistence
thin fluid to solid, but the solid bitumens are for the most part liquefiable at a mo
heat. The purest kind of fluid bitumen, called *Naphtha*, or *Rock-oil*, is a col
liquid of specific gravity 0·7 to 0·84, and with a bituminous odour. It often occ
nature combined with asphalt and other solid bitumens. *Petroleum* is a dark-col
fluid variety containing much naphtha. *Maltha* or *mineral tar* is a more
variety. The solid bitumens are *Asphalt*, already described (p. 425), *Mineral*
or *Hatchetin*, and *Elastic bitumen*, *Mineral Caoutchouc* or *Elaterite*. (See the s
substances in alphabetical order. For the practical uses of bitumen, see *Ure's D*
ary of Arts, Manufactures and Mines, i. 308.)

BIURET. $C^2H^5N^3O^2$ (dried at 100° C.); $C^2H^5N^3O^2.H^2O$ (crystallised
product of the decomposition of urea and nitrate of urea. It is isomeric
acid cyanate of ammonium, $2CHNO.NH^3$, and may be regarded as a seco
amide, $N\left\{\begin{matrix}(CH^2NO)^2\\ H\end{matrix}\right.$, whereas urea is a primary amide containing the same r
$N\left\{\begin{matrix}CH^2NO\\ H^2\end{matrix}\right.$, and isomeric with neutral cyanate of ammonium, $CHNO.NH^3$.

The formation of biuret from urea is represented by the equation

$$\underbrace{2CH^4N^2O}_{\text{Urea.}} = \underbrace{C^2H^5N^3O^2}_{\text{Biuret.}} + NH^3.$$

To prepare it, urea is melted in an oil-bath for some time at 150° to 170° C.;
soon as the evolution of ammonia ceases and the residue becomes pasty, this r
is treated with a very small quantity of boiling water; the liquid, after filt
is precipitated by a solution of subacetate of lead; the precipitate, consisting of
rate and ammelidate of lead, is separated by filtration; and the liquid, after
treated with sulphuretted hydrogen to remove the excess of lead, and again filt
evaporated till it crystallises. Biuret is then deposited in small granular cr
which may be purified by recrystallisation from water. It is also obtained,
in small quantity, by the action of heat upon nitrate of urea.

Biuret dissolves very easily in water and in alcohol, and crystallises from the
liquid in long anhydrous leafy crystals, and from water in hydrated crystals,
give off their water of crystallisation when exposed to dry air or dried at 100
dissolves without decomposition in cold strong sulphuric acid, and is not alte
boiling with nitric acid, unless the acid is very strong. Its solution is not preci
by lead or silver salts, by gallic acid, or by tannin. On adding a few drops of
tion of copper salt to a solution of biuret, and then a slight excess of potash,
red colour is produced. This reaction takes place also with solutions of biuret in
or in ammonia, and affords a very delicate test of its presence. Biuret when
melts, gives off vapours of ammonia, and ultimately leaves pure cyanuric acid:

$$3C^2H^5N^3O^2 = 2C^3H^3N^3O^3 + 3NH^3.$$

(Wiedemann, Pogg. Ann. lxxiv. 67.)

BIXIN. A colouring matter contained in annotto (the red paste obtain
crushing the seeds of the *Bixa orellana*). According to Chevreul, annotto co
two colouring matters, viz. *orellin*, a yellow dye, soluble in water and alcohol, bu
ingly in ether, and *bixin*, an orange-coloured dye, sparingly soluble in water, ea
alcohol and ether. According to Kerndt, bixin is $C^{16}H^{26}O^2$, and when exposed
air, and in the moist state, is partly converted into orellin. According to Pre
Ann. Ch. Pharm. lii. 382), bixin is obtained in small slightly yellowish crysta
treating lumps of pure annotto with carbonate of sodium, precipitating with
nitrate of lead, decomposing the precipitate with sulphuretted hydrogen, and eva
ing the colourless filtrate. It is bitter, soluble in water, alcohol, and ether, v
when heated, turned yellow by sulphuric and nitric acids, orange-yellow by ch
acid. Treated with ammonia in contact with the air, it is converted into a dar
brown substance, *bixeïn*, which is the red-colouring matter of annotto. It co
with lead-oxide and alkalis, and is turned blue by sulphuric acid. (Preisser.)

According to Girardin (J. Pharm. [3] xxi. 174), the name of bixin is
commercially to a variety of annotto, having six to ten times the colouring po

nnotto, a superiority which it appears to owe to a quicker process of

K BAND. A variety of carbonate of iron. See Iron and Carbonates.

K CHALK. This mineral has a bluish-black colour, a slaty texture, soils
, and is meagre to the touch. It contains about 64 silica, 11 alumina, 11
h a little iron and water. It is found in primitive mountains, and also some-
coal formations. It occurs in Caernarvonshire and in the island of Isla.

K JACK. The miners distinguish blende, or mock lead, by this name.
e of zinc.

K LEAD. See Graphite and Plumbago.

K WADD. One of the ores of manganese.

CHININE. The name of an alkaloid said to exist in *China blanca*.

QUETTE. A kind of crude soda, less powerful than barilla, obtained at
rtes, by the incineration of *Salsola Tragus* and *S. Kali*.

S OBTUSA. This insect contains, according to Hornung and Bley (J.
vi. 237), a red colouring matter, fatty and volatile oil, resin, formic acid,
chitin, wax, and other constituents.

CHING. The chemical art by which the various articles used for clothing
ed of their natural dark colour and rendered white.

est method of bleaching, which is still practised in some localities, and for
kinds of goods, especially for hempen and flaxen goods, consists in extending
on the grass of a meadow, so as to expose them for some days to the
on of light, air, and water, then washing them in alkaline ley, and repeating
of operations a considerable number of times.

ode of bleaching is effective, but slow, and involves a great amount of
bout 1785, Berthollet proposed the use of chlorine for bleaching vegetable
ut its introduction met with considerable opposition from manufacturers,
e mode of applying it being but imperfectly understood, its action was un-
d moreover it was found to injure the tissues; gradually, however, these
have been overcome, and the use of chlorine for bleaching cotton goods has
perseded the old method. Chlorine was first used in the form of aqueous
fterwards solutions of chlorine in caustic alkalis, that is to say, solutions of
te of potassium or sodium, the so-called chlorides of potash and soda, were
these compounds are now almost entirely superseded by the *hypochlorite of*
e so-called *chloride of lime* or *bleaching powder*. This substance is prepared
scale by exposing slaked lime to the action of chlorine gas, whereby a solid
hypochlorite and chloride of calcium is produced. It is soluble in water,
lution is used for steeping the goods to be bleached. By itself it exerts no
action whatever; but by exposing the fabrics wetted with it to the action of
ic acid in the air, or more quickly by steeping them in a bath of dilute sul-
hydrochloric acid, the salt is decomposed, and the liberated hypochlorous
its bleaching action on the tissues.

ngth of the chlorine-liquor is a matter of great importance. The stronger
the more rapid will be its action; but on the other hand, the greater will be
of injury to the goods. In practice it is not found safe to use a solution
ore than 2° or 3° of Baumé's hydrometer, or 0·5° of Twaddell's, equivalent
gravity 1002·5; and even this must be carefully removed by subsequent
nd in some cases by the use of hyposulphite of sodium or other antichlors.
HLOR.)

d silk are for the most part bleached with sulphurous acid, chlorine and
lorites being found to exert an injurious action upon them.

onale of bleaching is not thoroughly understood, but the most probable expla-
he action is, that it is due in all cases to oxygen in the peculiar active form
e. That active oxygen does possess this bleaching power is well-known:
e action of peroxide of hydrogen on vegetable colours. Now in the old
bleaching by exposure, light is an essential element of the action, the
taking place much more quickly in sunshine than under a clouded sky. But
s investigations have also shown that ordinary atmospheric oxygen passes
tive state under the influence of light and moisture. Chlorine abstracts
rom the colouring matter, and the oxygen thus set free produces the bleach-
The action of sulphurous acid appears at first sight to be apposite to
eoxidising; but it is known from Schönbein's investigations, that an aqueous
sulphurous acid or an alkaline sulphite exposed to air and light quickly
ortion of the oxygen in contact with it into the active state; hence also the
action may in this case be due to oxidation. Sometimes, however, the

sulphurous acid appears to unite directly with the colouring matter of the
form a colourless compound.

The actual process of bleaching by means of chlorine or sulphurous acid i
preceded or accompanied by certain cleansing operations, consisting in wash
water, and boiling with alkaline leys or soap, the object of which is to re
sinous, fatty, and other impurities, either natural to the fibre or introduced
ally or intentionally in the course of manufacture. All these substances i
whiteness of the fabric, and often interfere greatly with the processes of dy
printing. Indeed, their removal by the means above mentioned, constitute
important part of the bleaching process, a large portion of the colouring mat
got rid of at the same time, so that the chlorine or sulphurous acid serves to
the last finish. Cotton and linen goods are cleansed by washing with w
boiling with alkaline leys: formerly potash and soda were used for the pur
they are now nearly superseded by lime, at least for the first cleansing, as
stance, besides being much cheaper than the alkalis, is less likely to injure th
Silk and wool are cleansed by scouring or boiling with water and soap, as th
bear the action of pure alkaline solutions.

Bleaching of Cotton.—The series of operations in the bleaching of cotto
thus generally described:

1. Boiling, or as it is technically called *bucking* or *bowking*, with milk of
of lime to 14 lbs. of cloth, and about as much water as will cover the clot
operation converts the resinous and fatty matters into lime-soaps.

2. Washing with water, in the dash-wheel, or other suitable machine, t
the excess of lime and various soluble and mechanical impurities introduc
process of manufacture.

3. *Souring* in hydrochloric acid of specific gravity 1·010 or 2° Twaddle,
pose the lime-soaps and remove the lime. Dilute sulphuric acid is someti
but hydrochloric acid is preferable, as chloride of calcium is much more sol
the sulphate.

4. Washing again to remove excess of acid.

5. Bowking with a solution of soda-ash and resin (170 lbs. soda-ash, an
resin, to 3500 lbs. of cloth, and about the same quantity of water as in
process). An imperfect soap is thus produced, which removes the rest of
matter and dirt.

6. Washing, and then immersing the cloth in the chlorine-bath; this is cal
inating or *chemicking*. The solution, which should be quite clear, has
gravity of 1002·5 or $\frac{1}{2}$° Twaddle.

7. Souring in hydrochloric or sulphuric acid of 2° Twaddle, to set free
chlorous acid; then washing and drying.

The strength of the various liquors must be regulated according to the
the goods to be bleached, and the manner in which the operations are co
the preceding proportions of lime, soda, resin, &c. are given merely as exampl
times carbonate of soda is used in the cleansing operations, sometimes a m
soda-ash and quick lime, which of course produces caustic soda. It is oft
advantageous to perform the souring and chlorinating in two successive opera
goods being washed between the two. This treatment is found to be less
injure the fibre than long-continued exposure to the action of the liquid in o
tion. In all the operations, it is important to keep the cloth completely im
the liquid, and never to leave it exposed to the air before washing; becaus
or alkaline liquids, if allowed to become concentrated on it by drying, ar
destroy the fibre.

Bleaching of Linen.—Linen contains a much larger quantity of colouri
than cotton, and in bleaching loses nearly a third of its weight, whereas co
only one-twentieth. This large amount of colouring matter is not natural to
but is chiefly produced in the operation of steeping or *water-retting*, by
textile fibres surrounding the stem of the plant are separated from th
portion.

The colouring matter of steeped flax is insoluble in water, acids, and al
becomes soluble in alkalis after exposure to light or to the action of chlorin
rally speaking, it is not found advantageous to rely on the action of chlorine alo
bleaching of linen; the old method of exposure on the grass,—*crofting*, as it is
being almost always resorted to in addition. Moreover, it is not found possi
rid of the colour entirely in one series of operations, several alternate exp
oxygen or chlorine and to alkali being required to render the material
white.

The following is an outline of the Irish method, as practised in the neigh
of Belfast:

ping. — After the linen has been scoured in the fulling-mill, warm water is pon it, and it is left immersed for two or three days, till acid fermentation 2. Boiling with potash-ley, soda-ley, or lime-water.—3. Washing.—4. *Croft-* posure on the grass for two or three days.—2′, 3′, 4′. The bowking, washing ing are repeated several times, six repetitions sufficing for the finer linens, any as twelve being sometimes required for the coarser.—5. *Souring* with ric- or sulphuric-acid of 2° Twaddle.—6. Washing, as in 3.—7. Soaping, that g with solid soap or with very strong soap-suds.—8. Boiling in alkaline-ley of er cent.—9. Washing, as in 3 and 6.—10. Crofting for two days.—11. Chlo- vith a solution of hypochlorite of potassium, prepared by treating common powder with carbonate of potash. The liquor used is very weak.— ing, as in 3 and 6.—13. Souring, as in 5, but with somewhat weaker acid.— ing.—15. Soaping, as in 7.—16. Scalding, by immersing the cloth in soap- ed with a little potash-ley of ½° B., and heating the liquid to boiling.— ing.—18. Crofting.—19. Washing and drying.

ng of Silk.—Raw silk contains, besides the true fibre, about 40 per cent. of natter, viz. albumin, gelatinous substances, wax, fat, resin, and colouring These substances are removed by boiling the silk in a strong solution of n washing and rinsing. The silk after this treatment, is nearly white, but it quite white, it is sulphured, that is to say, suspended in the moist large box in which sulphur is burned. About 1 lb. of sulphur is required . of silk, and to obtain perfect whiteness, about four sulphurings, of twelve hours each, are required.

silk loses considerably in weight, when cleansed in the manner above de- t is sometimes thought better to subject raw silk to the bleaching process revious cleansing. For this purpose, a bath is used composed of 7 pts. hydro- cid and 3 pts. nitric acid, sometimes with addition of sulphuric acid, the ing diluted with water to 3° Bm. In this mixture, the skeins of silk are l, and repeatedly moved about for two or three hours, then wrung, twice nd afterwards sulphured. Sometimes the bleaching in the acid mixture is by softening in a soap-bath; sometimes this softening process is made to between the acid bath and the sulphuring.

ing of Wool.—Wool is never bleached in the fleece, because its whiteness destroyed in the subsequent operations of spinning and weaving; the bleach- erefore, always performed on the yarn or on the woven fabric. A consider- ion of the dirt which adheres to the wool while on the animal, is removed ashing which precedes shearing; this washing also removes the sweat, which of soap, chiefly composed of fatty matter and potash. But there still remains y of free fat, which is generally removed by steeping and agitating it for ten minutes in soap and water, or soda-ley, sometimes in putrid urine diluted or three measures of water, sometimes even in pure water. To prepare the spinning, it is then greased with oil, as, without this preparation, it would be and very liable to tear. The grease thus added must of course be removed ubsequent bleaching process. The treatment consists in passing the wool a soda-bath, then through a soap-bath, washing in lukewarm water, and n in the sulphur chamber, this series of operations being repeated several d finally passing the bleached wool through a blue-bath, which is a very weak of soap containing hydrate of alumina and indigo. The sulphuring is some- itted, and the cleansing is effected entirely by ammonia.

ing of materials for Paper.—The rags used for making paper are bleached in manner as cotton goods. After being properly sorted and chopped or torn , they are bowked with lime-water, soured, washed in the rag-engine, which bined washing machine and filter, then chlorinated, soured, and washed d finally treated with a solution of hyposulphite of sodium to remove the last chlorine. (See ANTICHLOR.)

leaching old paper: Boil the printed paper for an instant in a solution of da. Steep it in soap-suds, and then wash it; after which it may be reduced to he soap may be omitted without much inconvenience.—For old written paper rked up again: Steep it in water acidulated with sulphuric acid, and then vell before it is taken to the mill. If the water be heated, it will be more —To bleach printed paper without destroying its texture: Steep the leaves tic solution of soda, either hot or cold, and then in a solution of soap. them alternately between cloths, as paper-makers do thin sheets of paper ivered from the form, and subject them to the press. If one operation do not em sufficiently white, it may be repeated as often as necessary.—To bleach en paper without destroying its texture: Steep the paper in water acidulated huric acid, either hot or cold, and then in a solution of oxygenated muriatic

acid; after which immerse it in water, so that some of the acid may remain
The paper, when pressed and dried, is fit for use." *Ure.*

The *bleaching of straw* is effected by steeping it in hot water, heating it rep
during several days, and immersing it in weak solution of chloride of lime or c
alternately with weak alkaline leys.

Bleaching of Horse-hair.—White horse-hair requires further bleaching to ad
many purposes. The process consists in washing it in soda-solutions, not too
and at the heat of the hand, then hanging it up in the sulphur-chamber, and re
these processes several times.

[For further details, see *Dictionary of Arts, &c.*, i. 318, also *Muspratt's Ch*
i. 299.]

BLEACHING-POWDER. See HYPOCHLORITES, under CHLORINE.

BLEINIERITE. Basic Antimonate of Lead (i. 326).

BLENDE. Native SULPHIDE OF ZINC. (See ZINC.)

BLÖDITE. Probably the same as ASTRACANITE (i. 429).

BLOOD. The blood of the higher animals forms a rather viscous opaque
heavier than water, and of more or less intense red colour, arterial blood being
lighter than venous. It is transparent in very thin strata. The specific gra
normal human blood averages about 1·055; it is slightly less in women than i
and still less in children. The specific gravity of arterial blood is rather le
that of venous. The blood of most domestic animals differs but little in
gravity from that of man (specific gravity of bullock's blood = 1·060; of
= between 1·050 and 1·058). The blood has always an alkaline reaction.
warm it has a peculiar odour, generally more powerful in the male than
female.

From two to five minutes after the blood has left the circulation, it begins to
late, a film gradually extending from the surface and circumference, so that th
becomes gelatinous in the course of from seven to fourteen minutes. The co
(*fibrin* and *blood-corpuscules*) then gradually contracts and separates from the
portion of the blood (*serum*); and in from twelve to forty hours, the blood is con
resolved into serum and thick red clots, which swim beneath it. The blood
coagulates more slowly, but yields a denser coagulum than that of women
embryo it coagulates imperfectly. Arterial blood coagulates more rapidl
venous. The presence of air and a rise of temperature promote coagulatio
retards it.

The constituents of blood are partly in solution and partly suspended (blo
puscules). Swammerdam, in 1664, first observed corpuscules in the blood of th
he described them as oval. Leeuwenhoek (Phil. Trans. 1664, p. 23) found that
blood consisted of round bodies swimming in an opaline liquid, and that the co
matter of the blood of mammalia, fish, and frogs was contained in these corp
which were round in men, oxen, sheep, and rabbits, but oval in birds, frogs a
Later observers discovered that all blood-corpuscules are flattened. The c
corpuscules consist of a colourless enevelope, the contents of which are red, or by
mitted light yellow, and each is slightly depressed and concave in the cent
general they do not possess any nucleus, and only a few of them exhibit son
approaching to one. The size of the red corpuscules varies considerably in d
animals, the smallest being found in the blood of the *Moschus javanicus*, and h
diameter of 0·00208 mm. (Gulliver), and the largest in that of the *Cryptob*
japonicus (0·05623 mm. broad, and 0·0333 mm. long, V. d. Hoeven). The
corpuscules have a diameter of 0·00752 mm., those of the carnivora betw
and $\frac{1}{125}$ mm. and their thickness is generally $\frac{1}{4}$ or $\frac{1}{5}$ of their diameter. The
corpuscules of embryos are larger than those of the grown up animals of th
species. Milne-Edwards asserts that the size of the corpuscules is closely co
with the size of the organs of respiration. To prevent their shrinking up
measurement, C. Schmidt moistens a glass plate with an exceedingly thin laye
blood to be examined, so that it dries up immediately. The corpuscules thus
by their flat sides to the glass, and remain of this same size when the serum ha
up. The blood of different animals may frequently be distinguished under the
scope by the size of the corpuscules.

According to Schmidt, the specific gravity of the blood-corpuscules of a heal
varies between 1·0885 and 1·0889; in cholera it sometimes increases to 1·
1·1027. The red corpuscules *sink* in the serum; they are generally equally co
a few, however, are sometimes darker, sometimes lighter than normal corpuscule
difference in colour is dependent upon the absolute amount of hæmatin in

he proportion of which relative to the serum influences the general colour of
The form of the corpuscules also affects the colour of the blood, for if these
by addition of water, they become more spherical, and the blood appears of
olour. Mulder supposes that the bright colour of arterial blood is due to the
ckness of the enveloping membrane of the corpuscules. Nasse states that
ion of carbonic acid gas, the cells become darker in colour and turbid in the
ll substances such as caustic alkalis, and several organic acids, which burst
cules, or otherwise liberate their contents, turn the blood dark brownish-red,
e, such as nitrate and iodide of potassium, phosphate and carbonate of
c. which contract and so thicken the external membrane, render the blood
r colour.

rage proportion by weight of moist blood corpuscules in a healthy man =
7·2—54·2 %). According to Vierordt, 1 cubic millimetre of blood contains
corpuscules. The amount of dry corpuscules in the blood of man is variously
2·9 % (Prévost and Dumas), 14·1 (13·1—15·2 %) (Becquerel and
11·65 (Nasse). The blood of women contains fewer corpuscules than that
mounting to 36·924 % moist corpuscules (C. Schmidt), and 12·72 dry (11·3—
Becquerel and Rodier). The blood of middle-aged men and animals con-
corpuscules than that of older or younger individuals of the same species.
nt of corpuscules also varies in the blood of different animals, that of birds
most, that of the carnivorous and herbivorous mammalia less, and that of
ed animals by far the least, as will be seen from the following table, in which
tages of dry corpuscules are given:

cken.	Pigeon.	Ox.	Sheep.
and Du.)	15·57 (Pr. and Du.)	9·70 (Andral.)	9·35 (Pr. and Du.)
sse.)		12·18 (Nasse.)	9·80 (Andral.)
ggiale.)	14·30 (Poggiale.)	12·30 (Poggiale.)	9·24 (Nasse.)
			10·20 (Poggiale.)

og.	Frog.	Eel.	Carp.
and Du.)	6·90 (Pr. and Du.)	6·00 (Pr. and Du.)	8·23 (Berthold.)
sse.)	4·58 (Berthold.)		
ggiale.)			

rtion of corpuscules in the blood of different vessels also varies. In general,
lood contains fewer corpuscules than venous, the blood of the portal vein
n that of the jugular vein, while that of the hepatic vein contains far more
of the portal vein, jugular veins, vena cava or splenic vein (Lehmann).
found 55·652 % moist corpuscules in the arterial blood of a horse, 48·996 in
ood, 55·688 in that of the vena cava.

ient nourishment and long abstinence, as well as repeated blood-letting,
the quantity of blood-corpuscules; the amount increases if large quantities
taken in the food. It is also influenced by disease, a constant increase being
in plethora, in the earlier stages of heart-disease, in spinal irritation, and
. Decrease occurs in all cases where the consumption of blood is greater than
y, *e.g.* diarrhœa, intermittent fever, affections of the brain, and chlorosis
Becquerel and Rodier). The percentage of water in the corpuscules bears
constant relation to that of the serum, so that when the amount of water
in the serum, it also decreases in the corpuscules.

ess blood-corpuscules are always present in blood, but at least in the case of the
oded animals, in much smaller quantity than the coloured corpuscules. They
lly almost spherical, but sometimes lenticular; they have a granulated enve-
generally a round nucleus, which is more rarely oval or kidney-shaped, and
efracts light: sometimes it is formed of several small nuclei grouped together.
identical with the lymph- and chyle-corpuscules, and do not differ much
pus- and mucus-corpuscules. They are unelastic, and their envelope is so
at the corpuscules readily adhere to one another. They circulate less rapidly
od than the coloured corpuscules, and contain an albuminous liquid holding
te granules in suspension. Dilute acetic acid gradually dissolves the ex-
mbrane. In human blood they measure 0·01128 mm. in diameter. They
ically lighter than the red corpuscules, since they contain more fat and no
In healthy blood they bear to the red corpuscules the ratio of 1 : 1·373
s and Moleschott); the number increases during digestion and diminishes
, the increase commencing thirty minutes after partaking of food, and lasting
. They increase in certain diseases, frequently in pneumonia and tuber-
In leuchæmia this increase often amounts to one-fourth of the blood-corpus-
he splenic blood contains large quantities of colourless corpuscles, about one-
one-third of the total amount of corpuscules.

Gases.—As early as 1674, free gases were supposed to be dissolved in b
the question was finally set at rest by the experiments of Magnus. The
raised by Lagrange to Lavoisier's theory, that if combustion took place on
lungs, the other parts of the body would have a lower temperature, led him t
that the blood merely dissolved the inhaled oxygen, and afterwards distr
throughout the system. Fourcroy was, however, of opinion that combus
place principally in the lungs, and that only a part of the oxygen was di
the blood. H. Davy remarked that blood in contact with oxygen absorbs
quantity of the gas, giving off carbonic acid in exchange, and Nasse obse
blood in an atmosphere of hydrogen evolved carbonic acid. It has also been
that in an atmosphere of nitrogen, arterial blood evolves oxygen, but n
blood. Mayow, Vogel, and others, obtained carbonic acid from the blood
of the air-pump. Magnus also used the air-pump in his experiments, but
the gas under mercury, and found the gases in *arterial* blood to consist of
62·3% CO^2, and 23·2% O, in *venous*, 13·1% N, 71·6% CO^2, and 15·3% O.
undertook a series of experiments on the gases of blood, under the guidance o
The blood was diluted with ten times its bulk of water, and the gases were co
boiling the liquid in vacuo at a very gentle heat: the free gases were thus
A few crystals of tartaric acid were then added, and the blood again boiled
the combined gas was liberated. The following table contains the quantitie
(at 0° and 0·760m.) in 100 vols. of blood.

	Free Gas.	O.	N.	Free CO^2.	Combined CO^2.	Total CO
Art. Carot. (Dog) (1)	20·88	12·43	2·83	5·62	28·61	34·2
" " " (2)	25·50	14·29	5·04	6·17	28·58	34·7

Blood at 0° and 1 met. absorbs 1·151 vol. carbonic acid, besides 0·481 inde
of the pressure (combined CO^2). Defibrinated calf's blood, free from ai
under different pressures the same amount of oxygen (9·3% vol. at 0° and
Serum absorbs a much smaller proportion of gases than defibrinated blood.
colouring matter absorbs a considerable quantity of oxygen, and evolves a
bonic acid. G. Harley found that blood, or defibrinated blood, absorbed oxy
shaken up with air, and evolved carbonic acid, but in less quantity than cor
to the oxygen absorbed.

It is difficult to explain satisfactorily why blood should absorb so m
carbonic acid than pure water at the same temperature; it is perhaps partly
the neutral alkaline carbonate in blood forming acid carbonate, but this does n
for all the carbonic acid absorbed. Liebig has remarked that water contai
phosphate of sodium absorbs twice as much carbonic acid as pure water, wh
containing 15% chloride of sodium only takes up half as much. It is also
that oxygen, of which blood absorbs from 10 to 13% of its vol., and w
0·925%, combines in a loose way with blood, like nitric oxide with ferrous
since the vol. of gas absorbed does not increase proportionally with the
(Liebig). It has also been shown that part of the oxygen thus taken up
cannot again be separated. (See GASES, ABSORPTION OF.)

Constituents of the coloured blood-corpuscules.—Berzelius has s
the coloured corpuscules contain an albuminous substance (*globulin*) diffe
albumin. Schmidt separated the corpuscules by means of sulphate of so
found them to contain 87·59 globulin and 12·31% hæmatin. Mulder con
outer membrane of the corpuscules to be binoxide of protein, a hypothetical s
others have taken it for fibrin. Its composition does not appear to be fixed,
membrane of different corpuscules is variously affected by the same reagents.

Blood-crystals; Hæmatocrystallin.—O. Funke first completely investigate
ture of the crystalline substance of the red corpuscles. Funke and Kunde
crystals by adding to a drop of blood, water, ether, alcohol, or chloroform,
the mixture to dry slightly on a glass plate, and then covering the who
glass cover. Lehmann passes a slow stream of oxygen or nitrous oxide
fifteen minutes into a mixture of blood and water, and afterwards carbonic
the liquid turns bright red and becomes turbid, whereupon it crystallises.
considerable quantity of blood is to be operated upon, it is best to leave it to
press the clot to remove the serum, cut it in pieces, and wash it on a linen f
water till the filtered liquid amounts to about 1½ times or twice the volun
water used. The liquid is then to be poured into a glass cylinder, oxygen g
into it for about half an hour, and then carbonic acid for ten or fifteen mim
which it is left at rest. If no crystals form after about two hours, the liqui
mixed with ½ of its volume of alcohol (Lehmann). Light promotes the cryst
which is not caused by evaporation of water, since blood will crystallise a

ce its volume of water as with only half that quantity. It cannot be doubted h oxygen and carbonic acid, by their chemical action on the contents of the les, are instrumental in the formation of the crystals. The form of the varies in the blood of different animals; those obtained from the blood of st mammalia, and fish, form prisms; from the rat, mouse, and guinea-pig, rons; from the squirrel, hexagonal tablets; and from the German marmot, edrons (of about 120°), or very thin hexagonal plates.* The tetrahe-stals dissolve with peach-blossom-colour in 600 pts. of water, the pris-ith dark-red colour in 94 pts. water. Nitric acid turns the crystals almost it dissolves them on warming, and acquires a yellow colour. Their solution rised by chlorine, which precipitates white flakes; it is turned dark brownish-carbonic oxide, and rendered turbid and brownish-red by nitrogen. The ed crystals from the same blood often differ in intensity of colour and have not always the same composition. They seem to be an albuminous substance. olution of the tetrahedral crystals coagulates at about 63° C., that of the pris-ystals between 64° and 65°. The crystals exhibit, according to Lehmann's , the percentage composition of the albuminoïds:

arbon	55·41	55·24	55·18
ydrogen	7·08	7·12	7·14
itrogen	17·27	17·31	16·40
ulphur . . .	0·25	0·21	0·25
xygen . . .	19·99	25·12	20·03
	100·00	100·00	100·00

tin is peculiar to the blood-corpuscules of vertebrate animals, and in some way d with the remaining albuminous contents of the corpuscules. It is obtained norphous blackish-brown substance, by treating the corpuscules with sulphate m, extracting the residue with alcohol containing sulphuric acid, and treating monia, water, alcohol, and ether. It is insoluble in water, alcohol, ether, her, and oils, both fat and volatile, but readily soluble in alcohol containing c or hydrochloric acid. It is not dissolved by concentrated mineral acids. s or alcoholic solutions of alkalis or their carbonates dissolve hæmatin in all ons. A sulphuric acid solution of hæmatin which has been turned red by of alkali, exhibits dichroïsm, appearing green by transmitted and red by l light. If hæmatin be allowed to stand in contact with pure concentrated sul-cid, it may be obtained perfectly free from iron, without suffering any perceptible n its properties. Berzelius found in the dry blood corpuscules of men and 38 % metallic iron, and since Mulder has found 6·64 % iron in hæmatin, the les would contain 5·72 % hæmatin, and the blood 0·732 %. Becquerel and found in blood, 0·0565 % iron, and 14·11 % corpuscules, which would give . hæmatin to every 100 pts. corpuscules. In disease, the proportion of hæmatin whole blood probably varies with the corpuscules. It is not known whether a fixed relation between hæmatin and the albuminoïd of the corpuscules. assigns to it the formula $C^{44}H^{22}N^{3}O^{6}$. The arterial blood of the horse contains ess hæmatin than that of the outer jugular vein; the corpuscules of the liver-ontain far less than those of the *vena porta*. The proportion of iron to dry les in arterial blood = 1 : 394; in that of the jugular vein 1 : 390; of the rta 1 : 312; of the liver 1 : 500 (Lehmann.) Poggiale found 0·126 % ferric human blood, in that of the ox 0·125, calf 0·111, dog 0·145, sheep 0·106, chicken

stance called *hæmatoïdin* has been observed in blood extravasated in the tissues animals. It is sometimes amorphous, in grains and little globules; some-crystals belonging to the monoclinic system. It is transparent, strongly g, yellowish-red or ruby-red, insoluble in water, alcohol, ether, acetic acid, ute mineral acids. It generally turns ardent red on addition of potash, y disintegrates, and splits up into red granules, which gradually dissolve. natoïdin is not reprecipitated by neutralising the alkali. By the action of con-d sulphuric acid, the sharp contour of the crystals vanishes, and the colour of d concretions first turns brownish-red, then green, blue, and rose, and finally llow. In the liquid, iron may sometimes be detected, but not always. Ac-to Robin, its formula is $C^{14}H^{18}N^{2}O^{3}$.

ature of the *nuclei* which sometimes occur in the corpuscules is unknown.

nsiderable quantity of the *fat* of blood occurs in the corpuscules, nearly the f the so-called phosphorised fats being contained therein. Lehmann found nd 2·284% fat in the dry corpuscules from bullock's blood. The ethereal

res of these crystals are given in Funke's Atlas of Physiological Chemistry (Leipzig, 1853, also by the Cavendish Society); and in the Handwörterbuch der Chemie, 2te Aufl. ii. [2] 136.

extract of these corpuscules yielded 22 % acid ash, consisting of acid phosp sodium, from which it is probable that phosphoglyceric acid is contained in puscules. The corpuscules in the blood of different vessels do not contain t amount of fat. In the moist corpuscules of the carotid artery of the horse, we 0·608 % fat; in the external jugular vein 0·652 %; in the vena porta 0·752; blood 0·684. Dry corpuscules separated from arterial blood by sulphate of sodi tained 1·842 % fat; from venous blood 3·595 %.

The solid constituents of the corpuscules contain rather less than 6 % *e* *matter*, the nature of which is unknown. They also contain a free or loos bined nitrogenised organic acid.

Moist corpuscules contain on the average 68·8 % *water* (Lehmann). Tak account the amount of serum enclosed in the coagulum, the corpuscules contai smaller proportion of soluble *salts* than the serum. It will be seen from the ana Schmidt (p. 611), which are the most trustworthy, that the corpuscules cont cipally phosphates and potassium salts, and, in smaller quantity, chlorine, s acid, soda, and earths, while the serum contains proportionally less chloride of p and phosphate of sodium, and more chloride of sodium, sulphuric acid and ear man the moist corpuscules contain 0·7282 % salts. The blood of those anima contained most corpuscules also contains most alkaline phosphates (Nasse corpuscules contain less earthy phosphates than the serum. Iron belong exclusively to the red corpuscules (hæmatin). Clear serum contains no iron. and Schmidt).

Fibrin. — As already stated, the spontaneous coagulation of the blood i by the separation of the fibrin, which at the same time encloses all the co and a portion of the serum. As soon as the blood has left the body, a film on the surface of the liquid, extending in the form of a star, from the side vessel towards the centre; a clot, adhering to the sides of the vessel, the Often, within two minutes after the blood has been collected, it become and gelatinous, and after a time a few drops of liquid, gradually increasing in c separate from the jelly, till the coagulum swims in the serum. According to stances the coagulum is more or less contracted, consistent, viscous, and ela the coagulation be observed under the microscope, exceedingly fine straight will be seen to shoot out from various points between the corpuscules, and, g increasing in length, to cross one another, so that finally the whole forms a enclosing the corpuscules. If the amount of fibrin is small in comparison to puscules, the coagulum is comparatively light; denser, on the contrary, when the of fibrin is large. A large quantity of water diminishes the consistence of the c Various salts have the property of retarding or entirely preventing the coagu blood. The alkalis and their carbonates and acetates have this effect, an strong solutions of nitrate of potassium, nitrate of calcium, and chloride monium in a less degree. Most dilute acids also maintain the fluidity of blood they render it rather more viscous. The venous blood of a healthy man between 0·203 and 0·263 % fibrin (Scherer), 0·220 (average, Becque Rodier), 0·250 % (Denis). Arterial blood contains more fibrin than venou FIBRIN.)

Constituents of the Serum.—The average specific gravity of serum = 1· less variable than the specific gravity of blood. The amount of *water* in th varies between 88 and 95·6%, averaging 90·5 or 90·6 % (Nasse). Wome contains more water than that of men. According to C. Schmidt, the serum contains 90·884 % water, and that of woman 91·715; and, according to N serum of pregnant women is more aqueous than of others. At an advanced amount of water increases considerably. The following table contains the per of water in the serum of different animals:—

Ox.	Sheep.	Dog.	Chick
90·8 (Nasse.)	91·5 (Du. and Pr.)	92·6 (Du. and Pr.)	92·5 (Du.
91·6 (Berthold.)	91·8 (Nasse.)	91·2 (Nasse.)	93·1 (Nass

Pigeon.	Frog.	Eel.
94·5 (Du. and Pr.)	95·0 (Du. and Pr.)	90·0 (Du. and Pr.)

According to most observations, the serum of arterial blood contains more wa that of venous blood. Simon found in the arterial blood of two horses, 2·734 water than in the venous blood, and, according to Nasse, arterial blood contai more water than venous. As a general rule, the amounts of water in the se of corpuscules in the blood are inversely proportional. An absolute dimin water has only been remarked in cholera.

Albumin is the most abundant of the constituents of the serum, amounti tween 6·3 and 7·1% of normal blood, and between 7·9 and 9·8 % of norma Neutral albuminate of sodium, which becomes turbid on addition of water, oc

urbid blood, but also in the blood of the spleen. The serum of the blood of
porta gives less turbidity, and that of the liver-blood more, than of the
When the alkaline serum of liver-blood is neutralised with acetic acid, the
does not coagulate on boiling till after several hours, while that of the vena
other veins, as well as of the arteries, speedily coagulates on addition of
d and boiling. Hoppe is of opinion that the albumin in serum is not dis-
t merely suspended in a state of fine division. According to Becquerel and
ormal man's blood contains 6·94 % (6·2—7·3 %) albumin, and that of women
—7·55) %. The blood of pregnant women was found to contain from the 2nd
h month, 7·0—6·8 % albumin, and in the last two months, 6·8—6·4 %. (J.
lt). Arterial blood contains less albumin than venous, and the amount in
d increases considerably during digestion; it decreases in scurvy, puerperal
Bright's disease, and increases in intermittent fever, cholera, &c. In typhus,
ed to 6·5 %, and in Bright's disease to only 4·93 %.

-But few free fats are found in serum; they occur chiefly saponified. Che-
Babington first discovered the presence of normal fats in blood. Oleic, mar-
stearic acids, both free and saponified, have been detected in the serum of
blood, and cholesterin is constantly present. Boudet describes, as a fat peculiar
rum, a substance extracted from its residue by hot alcohol (serolin), which
nsiders as a mixture of oleïn, margarin, cholesterin, and cerebrin. According
ul, phospholeïc acid (cerebrin) is contained in the fibrin and serum. Compared
corpuscules, that of the serum is more crystalline, less viscous, and colour-
rmal serum contains 0·2 % fat, and its solid residue 2·22 % (Simon, Nasse,
el). The amount of fat in the blood is not increased by food rich in fat, nor
nished by nourishment free from fat. During digestion, the amount of fat
nd in the blood of the vena porta, has been found to increase considerably, so
onally to render the serum turbid. According to Becquerel and Rodier, the
omen contains 0·57 p. m. fat and soaps, and that of men 0·69 p. m. Serum of
lood contains less fat than that of venous, and the vena porta blood is richer
jugular. Becquerel and Rodier have found that, almost at the commencement
cute disease, the proportion of fat (especially cholesterin), in blood increases, as
some chronic diseases, particularly in liver diseases, Bright's disease, tuber-
nd cholera.

is known of the *extractive matter* of the serum; it varies between 0·25 and
Lehmann found more in the arterial than in the venous matter of the horse.
(grape-sugar), is a normal constituent of blood. The blood of the vena porta
but traces, while that of the liver contains larger quantities. In normal
blood, it varies between 0·00069 and 0·00074 % (Lehmann). The blood
contained 0·0015, and of a cat 0·0021 %. In the blood of diabetic patients
never detected more than 0·047 % sugar. The amount varies with the nature
od. *Urea* occurs in healthy blood to the amount of 0·0142—0·0177 %. It
detected by evaporating large quantities of serum and adding nitric or oxalic
e residue. The quantity increases considerably in Bright's disease (1·5 %
Bright and Babington), and in cholera (0·14 %). *Uric acid* has been
the blood of healthy as well as of diseased persons. Garrod found between
d 0·0055 in the serum in a case of Bright's disease. *Creatine*, *creatinine*, *hip-*
d, and *hypoxanthine*, have also been detected. According to Musing, *alcohol*
detected in the blood of men who had died from drinking brandy. Ma-
ates that goat's blood warmed with sulphuric acid evolves *caproic acid*.
as detected *lactic acid* in a case of puerperal fever. Fourcroy and Vauquelin
s state that they have found bile-constituents in healthy blood; they some-
ur in morbid blood. *Leucine* and *tyrosine* occur in small quantities in liver
al blood, in diseases of the liver. Little is known of the *colouring matters*
the serum. An intense yellow coloration of the serum is often due either
igment, which may be detected not only in icterus, but also in pneumonia.
arcely yellow, brown, or red granules of pigment are said to have been de-
the heart, large vessels, liver, and spleen, after intermittent fever. Blood con-
tral carbonate of sodium (0·1628 % in bullock's blood, Lehmann), probably
arbonate (Lehmann, Liebig). Meyer concludes from his experiments that
present as acid carbonate. Blood seldom contains *sulphates*, and never more
es; it contains *silicic acid* (Millon), and according to G. Wilson, traces of
Normal blood never contains *ammonia*, but that alkali is sometimes found in
cholera, &c.)

—The serum of man's blood contains 0·88 % (av.) salts, that of women
Lehmann gives the following composition of the ash according to the best
61·087 % chloride of sodium, 4·085 chloride of potassium, 28·880 carbonate

of sodium, 3 195 phosphate of sodium (Na^2HPO^4), 2·784 sulphate of potassiun
serum of grown-up animals contains more salts than that of the young; the s
the calf, however, contains 1·12 % salts, while that of the cow contains 0·99, an
ox 0·87 % (Nasse and Poggiale). The blood of cats, goats, and sheep, conta
most salts; of birds, men, and pigs, less; and of dogs and rabbits the least. Arteri
serum is somewhat richer in salts than venous, and the serum of portal blood
considerably more than that of the jugular vein. The kind of nourishment h
influence on the amount of salts, and of their several constituents. Plouviez a
giale found that in the blood of animals to whose food common salt had bee
for several months, the percentage of salt rose from 0·44 to 0·64, an increase du
to chloride of sodium. The amount of salts is also greatly influenced by diseas
particularly small in violent inflammations, and increasing in typhus, &c.
found 1·19 % *silica* in the ash of bullock's blood.

The amount of salts, exclusive of iron, in man's blood = 0·728 %, woma
dog 0·713 %. Some chemists think they have detected *manganese* in blood,
presence is doubtful. Millon found *copper* in the blood of soldiers whose f
been prepared in copper vessels, and others have detected traces in the blood
and beasts. It is said always to occur in the ash of the blood of *Limulus*
Millon also detected *lead* in blood.

ANALYSIS OF BLOOD.—The amount of *water* in blood is easily estimated b
rating a weighed quantity, and drying the residue at 120°—130° C.

To determine the *fibrin*, the blood, as it runs from a vein, is received in
vessel, and stirred for 5 to 10 minutes with a glass rod, the weight of whic
cluded in the tare, till the fibrin is completely separated. The blood, toget
the separated fibrin, is then weighed, strained through linen, and the fibri
remains thereon is placed for some time in water, then dried, well boiled with
and ether, to free it from fat, and weighed after drying at 120° C. (Becque
Rodier).—Another method of estimation is to leave a weighed quantity of
coagulate at rest, tie up the clot in a fine linen bag, after it has contracted
as possible, knead it first by itself, afterwards with water, and treat the re
above. (Scherer.)

Estimation of Albumin and other Matters coagulable by Heat.—A weighe
tity of the blood, slightly acidulated with acetic acid, is added by drops to
water, the liquid is poured through a weighed filter, and the coagulum c
thereon; it is then washed on the filter with boiling water, and dried, first at
heat, afterwards at 120° to 130° C. The residue may be freed from fat by tr
with boiling ether. If the blood had not been previously freed from fibrin, th
of that substance, determined as above, must be deducted from the total weigh
coagulum.

Estimation of the Extractive Matter.—The filtrate obtained in the last deter
is evaporated on the water-bath in a tared platinum basin, the residue dried at
weighed, and burnt in a muffle at as low a heat as possible. The weight of
deducted from that of the total dried residue, gives approximately the amoun
tractive matter.

Estimation of Fat.—A quantity of blood (which need not be weighed) is
100° C., the residue is pulverised and dried at 120°, and a weighed portion t
treated with ether in a flask: the ether is passed through a small filter into
platinum capsule; and the treatment of the residue with ether is repeated severa
The collected ethereal solution is carefully evaporated, and the residue dried at
As the weight of the solid constituents of the blood has been previously dete
the quantity of blood from which this amount of fat has been obtained may
culated from that of the residue which was subjected to treatment with ether.

Estimation of Mineral Constituents.—A weighed quantity of the blood i
mixed with ignited carbonate of sodium, then dried and incinerated in the
the lowest possible temperature. (See ASH OF ORGANIC BODIES, p. 418.)

Separate Estimation of the Serum and Coagulum, with their Constituents
fresh blood is collected in a tared cylindrical vessel, having a ground edge,
too shallow; it is covered with a glass plate and left to stand till the coagu
complete, after which the edge of the clot is detached from the side of the
eans of a needle. The blood is then weighed, and after the clot has contr
uch as possible, the serum is poured off, and the quantity of albumin, &c.,
it is determined as above described. The clot and the inner surface of t
are then freed from serum as completely as possible by wiping with bibulou
and the clot is weighed on the vessel. This weight, deducted from the total
the blood, gives the proportion of serum.

The clot contains the blood-corpuscules, the fibrin, and a certain quantity o
the amount of water contained in it may be determined by drying at 120° to

e is no known method of directly estimating the amount of the blood-cor- Prevost and Dumas estimated it approximately on the assumption that the ntained in the clot is all due to adhering serum, and accordingly deducting weight of the dried clot an amount of serum-constituents corresponding to the of water in the clot, together with the amount of fibrin separately determined. ver, the blood-corpuscules themselves contain water, this method necessarily he quantity of dry corpuscules too small.

ling to C. Schmidt, the clot contains a quantity of serum amounting to ⅓ of its and the weight of the moist blood-cells is four times as great as that of the as determined by the method of Prevost and Dumas. Hence, when the con- of the serum and coagulum have been determined as above, and from the f the coagulum, a deduction is made of the quantity of serum-constituents ding to ⅓ of the weight of the moist coagulum, the composition of the cor- may be calculated.

paration of hæmatin from globulin cannot be effected; but if the quantity of the dry coagulum be determined, the amount of blood-pigment may be cal- n the supposition that this pigment contains 6·64 per cent. of iron. (Strecker, d. Chem. ii. [2] 115).

0 pts. Blood-corpuscles contain:		1000 pts. Serum contain:	
	688·00	Water	902·90
stituents	312·00	Solid constituents	97·10
y	1·0885	Density	1·028
n	16·75	Fibrin	4·05
and membrane of cor- cules	282·22	Albumin	78·84
	2·31	Fat	1·72
ve matter	2·60	Extractive matter	3·94
matter (without iron)	8·12	Mineral matter	8·55
ne	1·686	Chlorine	3·644
ric acid	0·066	Sulphuric acid	0·115
horic acid	1·134	Phosphoric acid	0·191
ium	3·828	Potassium	3·323
n	1·052	Sodium	3·341
n	0·667	Oxygen	0·403
hate of calcium	0·114	Phosphate of calcium	0·311
hate of magnesium	0·073	Phosphate of magnesium	0·222

ean Composition of Male and Female Blood (Becquerel and Rodier).

	Male	Female.
ensity of defibrinated blood	1060·00	1017·50
ensity of serum	1028·00	1027·40
Vater	779·00	791·10
ibrin	2·20	2·20
atty matters	1·60	1·62
erolin	0·02	0·02
hosphorised fat	0·49	0·46
holesterin	0·09	0·09
aponified fat	1·00	1·04
lbumin	69·40	70·50
lood-corpuscules	141·10	127·20
xtractive matters and salts	6·80	7·40
Chloride of sodium	3·10	3·90
Other soluble salts	2·50	2·90
Earthy phosphates	0·33	0·35
Iron	0·57	0·54

1000 pts. Blood contain (Schmidt):

	Man.	Woman.	Dog.
rpuscules	513·02	396·24	543·56
	486·98	603·76	456·44

Salts in 1000 pts.:

	Corpuscles.	Serum.	Corpuscles.	Serum.	Corpuscles.	Seru
Sulphate of potassium	0·132	0.281	0·157	0·217	0·309	0·302
Chloride of potassium	3·679	0·359	3·414	0·447	0·567	0·118
Chloride of sodium	—	0·546	—	5·659	2·485	5·343
Phosphate of potassium	2·343	—	2·108	—	—	—
Phosphate of sodium	0·633	0·271	—	0·443	2·803	0·211
Potassa	—	—	0·857	—	—	—
Soda	0·341	4·532	2·205	1·074	0·861	1·726
Phosphate of calcium	0·094	0·298	0·218	0·550	0·110	0·841
Phosphate of magnesium	0·060	0·218				

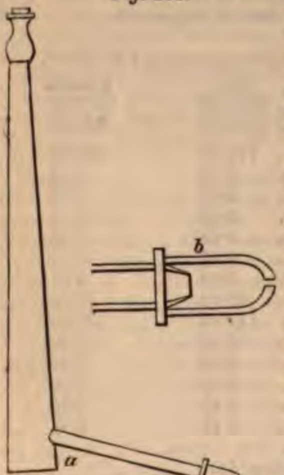
C. E. L.

BLOODSTONE. A variety of Jasper (*q. v.*)

BLOWPIPE. An instrument for directing a stream of air through a flame, eith by blowing with the mouth or with bellows. The flame of a candle, of a lamp wi a simple wick, or of an ordinary gas-jet, consists of three parts. The dark centr portion immediately surrounding the wick or burner, consists of combustible gaseo matter, not yet burned; this is surrounded by a highly luminous cone, which deposi soot on a cool body held within it; and outside of all is a thin pale blue envelop which gives little light, but has a very high temperature. It is here that the combu tion is most complete, the carbon and hydrogen finding sufficient oxygen to conve them into water and carbonic acid. But in the middle luminous cone, the supply oxygen is not sufficient for complete combustion, and consequently the hydroge which burns most easily, takes up the whole or the greater part of it, while the carb is set free in the form of minute solid particles. If now a jet of air be directed throug the middle of the flame, a double combustion takes place, the combustible matte uniting on the outside with the oxygen of the air, and in the interior with that whic is supplied by the blast. In this manner, an intensely hot flame is produced, appl cable for fusions, reductions, and a variety of operations in chemical analysis; an likewise for soldering metals and working glass.

The best and cheapest form of the mouth-blowpipe for chemical purposes, is that in vented by Black. It consists of a tube of tin-plate (*fig.* 101), about 7 inches long, and $\frac{5}{8}$ an inch broad, tapering to $\frac{1}{4}$ of an inch, where a sma mouth-piece is soldered. At the wide end a inserted a small cylindrical tube of brass, about in. long, supporting the nozzle, which may be brass or platinum.

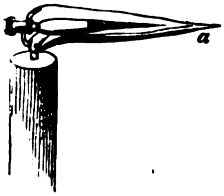
Fig. 101.



The tube is slightly conical at the end wher the jet is fixed, and the latter is thus made to f on without a screw, which would soon be injure by the high temperature to which it is expose and would then be difficult to remove for th purpose of cleaning. The nozzle is drilled from solid piece of metal, and in the form shown at *b* i the figure. One of the chief excellencies of thi form of blowpipe, is the efficient manner in whic it condenses and retains the moisture of the breath and prevents its projection on the heated assay The blowpipe may also be provided with a mov able trumpet-shaped mouthpiece, against which th lips, partially open, may be pressed during the ac of blowing; in this manner, a strong blast may b kept up for a considerable time with very littl fatigue. The use of such a mouthpiece is strongl recommended by Plattner in his valuable treatis on the blowpipe; but it is scarcely necessary, ex cepting when the blast has to be kept up for a lon time, as when the blowpipe is used for quantitativ analysis.

To use the mouth-blowpipe with success, it is necssary to acquire the art of keepin up a steady blast of air for some time. For this end, the air must be supplied fro the mouth, not directly from the lungs, which could not, without fatigue, afford sufficient stream. The mouth-piece of the instrument being placed between the lip the mouth is to be filled with air till the cheeks become distended as in playing on wind instrument. The current of air is then forced through the tube by the action o the muscles of the cheeks, and during the blast, the communication between the che h is closed, respiration being carried on through the nostrils. The mode of his is difficult to describe, but the right method of blowing is easily acquired practice.

Fig. 102.

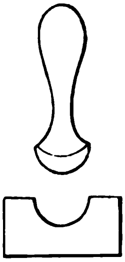


ality and intensity of the flame vary considerably according to the strength ion of the blast. If the nozzle of the blowpipe is inserted into the middle of a little above the wick, as shown in *fig.* 102, ted flame is produced, consisting of an outer ner cone, the former having a yellow, the latter our. The outer flame is an *oxidising* flame. ble substance, such as lead or copper, placed beyond the point *a* of this flame, is strongly contact with the oxygen of the air, and is brought just into the condition for taking up The greatest heat is at the point of the inner combustible gases being there supplied with uantity of oxygen required to consume them; en this and the point of the exterior flame, is y of combustible manner, very hot, but not d, and therefore disposed to take oxygen from any compound containing that This part of the flame is therefore a *reducing* flame. A piece of ordinary aining lead, turns black and opaque when heated in this part of the flame, ence of the reduction of the lead; but by afterwards heating it in the outer lead is reoxidised, and the transparency restored.

reducing power of a flame produced in the manner just described, is not , as any one may convince himself by trying to reduce oxide of copper or n in it without the aid of a reducing agent. The flame is for the most part ng flame, especially if the aperture of the blowpipe is large and gives a good air. To obtain a good reducing flame, it is necessary to use a blowpipe with perture, and to adjust the point, not within, but just outside the flame, and ther over than through the middle of the flame. In this manner, the flame red in its general characters than in the former case, the chief sting of a large and luminous cone, containing a considerable f free carbon in a state of intense ignition, and just in the for taking up oxygen.

ces to be heated in the blowpipe flame, are supported, some- charcoal, sometimes in spoons or forceps made of platinum, inum foil or wire, sometimes on small capsules made of clay rth. Charcoal is used chiefly in experiments of reduction. tance to be heated is placed in a small hole scooped in the charcoal, not at the ends, because in the latter position, it kely, when in the fused state, to sink into the pores of the Clay basins are chiefly used in the quantitative assaying They are made of fire-clay kneaded into a stiff paste with ssed into shape in a box-wood mould (*fig.* 103), then dried ned. Instead of these, however, very thin porcelain basins, y be procured ready made, may be used with advantage. cupels of bone-earth made in a similar manner, are used for cupelling silver with lead. The oxide of lead formed in the process, sinks into the porous sup- ng the silver or gold in the form of a metallic button.

Fig. 103.



PE ANALYSIS.—The blowpipe is an indispensable instrument in qualitative s it serves to recognise the presence of many substances with greater facility nty than could be obtained by analysis with liquid reagents, especially when the f substance to be operated on is but small. Generally speaking, however, it to trust to the indications of the blowpipe alone, inasmuch as many substances ndistinct reactions when submitted to this mode of examination, and are apt pletely overlooked when present together with others whose indications are ided. In a mixture of iron, nickel, and cobalt, for example, it would be ossible by the blowpipe alone to recognise anything but cobalt, even though l might be present in small proportion only as compared with the others. It erefore, to use the blowpipe, and in general, the mode of analysis by the dry means of determining the general character of a compound or mixture, and certain of its constituents, and thus obtaining an indication of the best roceeding with the more complete analysis by the wet way.

ise account of the behaviour of the several elementary bodies, and their inorganic compounds when heated *per se*, and with certain reagents, is given icle ANALYSIS (INORGANIC), (p. 213); and these characters will be described detail in treating of the several elements and compounds. The table on

Behaviour of Metallic Oxides before th

A clear bead is formed by fusing the flux on a loop made at the end of a platinum-wire
in the reducing flame, it is sometimes advisable to employ charcoal instead of platinu
employed. In this table h. signifies hot; c. cold; supera. that the

Colour of the Bead.	With Microcosmic Salt.	
	In outer or oxidising Flame.	In inner or reducing
Colourless.	*Silica* swims undissolved. *Alumina, Stannic oxide.* All *Alkaline earths,* and *Earths* (supera. opaque). *Tantalic, Columbic, Titanic, Tungstic anhydrides; Zinc-, Cadmium-, Lead-, Bismuth-, Antimony-oxides* not sat.: (supera. yellowish).	*Silica* swims undissolved. *Al* *alkaline earths* and *earths* (su *Ceric, Didymic, Manganic, St*
Yellow or brownish.	h. not sat. *Ferric* and *Ceric oxides.* h. *Vanadic anhydride, Uranic oxide, Oxide of Silver.* c. *Nickel-oxide.*	h. *Ferric oxide* (reddish), *Tit*
Red.	h. *Nickel-oxide.* h. supera. *Ferric* and *Ceric oxides.*	h. *Ferric oxide.* c. *Titanic* *anhydrides containing iron* *Cupric oxide.*
Violet or Amethyst.	*Manganic* and *Didymic oxides.*	c. *Titanic anhydride. Colu* *dride* (not sat.).
Blue.	*Cobalt-oxide.* c. *Cupric oxide.*	*Cobalt-oxide. Tungstic anhy* *obous anhydride* (supera.)
Green.	h. *Cupric oxide, Molybdic anhydride, Ferric oxide containing cobalt or copper. Chromic* and *Uranic oxides.*	*Chromic* and *Uranic oxides,* *Molybdic anhydride.*
Grey and Opaque.		c. *Oxides of Silver, Zinc, Cad* *Bismuth, Antimony: Telluro*

with Microcosmic Salt and Borax.

into the finely-powdered substance under examination, and again heated. In heating
the bead frequently varies with its temperature, and with the quantity of oxide
d with oxide ; not sat. that it is not completely saturated with oxide.

With Borax.	
outer or oxidising Flame.	**In inner or reducing Flame.**
Alumina, Stannic oxide.*—Supers.** **:** ***Alkaline earths* and *Earths, Oxide ***er, Tantalic, Columbic, Tellurous*** ***ides.*—Not sat.:** ***Titanic, Tungstic,*** ***dic anhydrides, Zinc-, Cadmium-,*** ***Bismuth-, Antimony-oxides.***	***Silica, Alumina, Stannic oxide.*—Supers. opaque:** ***Alkaline earths* and *Earths, Lanthanic and Ceric oxides, Tantalic anhyd. Manganic* and *Didymic oxides.*** **h.** ***Cupric oxide.***
adic anhydride. **h. not sat.** ***Ferric*** ***Jranic oxides.*** **h. supers.** ***Lead-,*** ***th-,* and *Antimonious oxides.***	***Tungstic anhydride; Titanic, Vanadic,* and *Molybdic anhydrides* (brownish).**
ic* and *Ferric oxides. **c.** ***Nickel-*** **(red-brown). h. supers.** ***Chromic***	**c.** ***Cupric Oxide* (supers. opaque).**
mic* and *Didymic oxides. Nickel- ***containing cobalt.***	
-oxide. **c.** ***Cupric oxide.***	***Cobalt-oxide.***
omic oxide, Vanadic anhyd. **h.** ***Cu-*** ***ride, Ferric oxide containing copper*** ***alt.***	***Ferric, Uranic, Chromic oxides.*** **c.** ***Vanadic anhydride.***
	The same as with microcosmic salt. Also ***Nickel-oxide,* and (supers.)** ***Columbous anhydride.***

page 614 (taken from Conington's "Handbook of Analysis,") exhibits in a conven form the colours imparted by metallic oxides to borax and microcosmic salt, heated therewith in the oxidising and reducing flames. [For further details, "Chemical Manipulation," by C. Greville Wlliams, London: Van Voorst; also, pecially for the method of Quantitative Analysis with the blowpipe: Plattner's " bierkunst mit dem Löthrohre," or the translation of that work "On the Use of the B pipe, &c.," by Dr. Muspratt, London, 1850.]

Table Blowpipe.—For sealing and bending glass tubes and constructing apparatus of various forms, it is convenient to have the blowpipe mounted on a support, and when a flame of considerable power is required, the blast must be plied by bellows worked with foot. A very convenient for blowpipe for these purposes is invented by Herapath, and r presented in *fig.* 104. *a* is a fle tube attached to a stopcock *b*, communicates with a tube *c d*, at right angles at *d*, where shaped tube *e f g* slips on by m of the piece *f*. The blowpipe j passes into the longer arm o T-piece, and fits somewhat tig *k l* is a second piece of fle tube terminating in a mouth- or connected with a blowing ratus. On turning on the g passes in the direction marke the arrows, and is to be inflam *e*. On blowing with the mout by means of a pair of bellows int tube *k l*, the ignited gas take form of a blowpipe flame of power, the nature of which i tirely under control by means o stopcock *b*, and also by regul the quantity of air supplied thr the tube *k l*. The T-shaped pi moveable at *f*, so that the jet be directed to any position. apparatus may be mounted on a heavy foot, and connected with the gas-suppl means of the flexible tube, so that it can be placed in any required position on the tory table; or it may be permanently fixed on a table specially devoted to the pu and having beneath it a pair of bellows worked by a treadle.

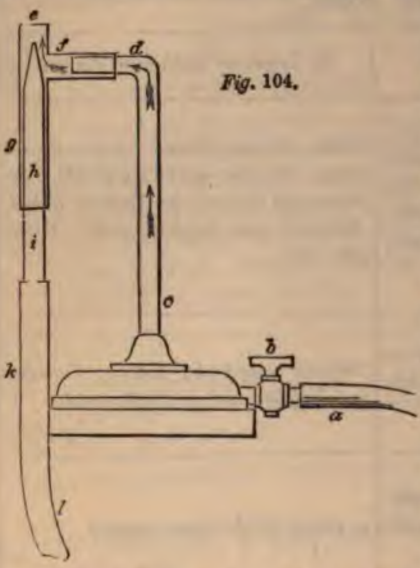
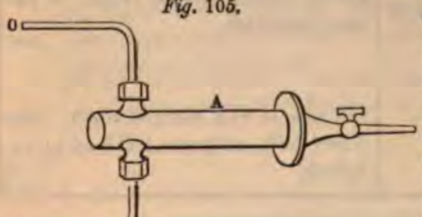


Fig. 104.

Oxyhydrogen Blowpipe.—The power of the blowpipe flame may be immensel creased by supplying it with oxygen gas instead of atmospheric air. The appa last described is very well adapted for the purpose, the flexible tube *k l* being nected with a gas-holder containing oxygen. As the oxygen and the combustib would meet only at the very place where the combustion is to take place there be no danger of explosion. Still greater intensity of heat is obtained by a flame posed of pure oxygen and hydrogen in the proportions required to form water. N rous forms of apparatus have been contrived for burning this gaseous mixture object being so to contrive the jet that the gases shall be there mixed in the proportions required, and at the same time to prevent danger of explosion by p ture mixture. The best form i shown in *fig.* 105, in which A brass tube filled with a numb layers of wire gauze pressed c together, or with a bundle of thin brass wires placed paral the axis of the tube, and t wedged together by a stout c wire driven into the middle, so form a collection of extremely n tubes. The gases are supplie the tubes O H, connected wit holders or loaded caoutchouc one containing oxygen the other hydrogen. To the other end of the brass t

Fig. 105.



a jet, the extremity of which is formed of platinum. The gases mix in and pass on through the meshes of the wire-gauze or the interstices behin brass wires to the point of the jet, where they are set on fire. The in which the gases are supplied are regulated by stopcocks on the tubes appearance of the flame, which should be a very narrow cone of a pale blue cates when the right proportion is attained, and this having been once , the position of the stopcocks may be marked, so as to ensure the right of the two gases in all future experiments. The use of the wire-gauze or thin wires in the tube A is to supply a mass of good conducting material, prevent the flame from passing backwards through that tube (see FLAME). roduced by the oxyhydrogen flame is the greatest that can be produced by l means, except by the electric current. Thick platinum wires melt in it like flame of a candle. By itself, however, it gives but little light; but any non-l incombustible solid substance held in it becomes intensely luminous. If f the flame be directed on the rounded edge of a cylinder of quick lime, a light of dazzling brilliancy is produced, inferior only to the electric light. the *Drummond light*, and has been used for lighthouses.

PRUSSIAN. See CYANIDES OF IRON.

SAXON. The best Saxon blue colour may be made with the following : mix one ounce of the best powdered indigo with four ounces of sulphuric lass bottle or flask, and digest it for an hour at the heat of boiling water, e mixture at different times; then add 12 oz. of water, stir the whole well, when cold. Poerner adds 1 oz. of good dry potash at the end of twenty- and lets this stand as much longer before diluting with water. The cloth prepared with alum and tartar.

ITE. A mineral related to allanite, discovered by Kerndt in the oli-tween Boden and Mauersberg, near Marienberg in Saxony. Found only in prisms [rhombic?] of 110° to 112°, without trace of cleavage. Hardness fic gravity 3·523. Reddish or blackish-brown. Streak dirty white. Opaque us lustre. When strongly heated, it exhibits incandescence like gadolinite. y on the acute edges. Decomposed by strong acids. Analysis gave: 26·12 3 Al^2O^3; 12·04 FeO; 17·44 YO; 10·46 CeO; 7·56 LaO; 1·61 MnO; 6·32 MgO; 1·21 K^2O; 0·84 Na^2O; and 3·01 H^2O: whence may be deduced the 3M″O.SiO²) + 2Al^2O^3.SiO^2, the water being regarded as basic. Associated nineral are found black amorphous grains of another mineral, *Maromontite*, the same elements, but not exhibiting incandescence when heated. (Kerndt, n. xliii. 219, 228.)

UTTER. A fatty substance found in the peat-bogs of Ireland. It was ned by Luck (Ann. Ch. Pharm. liv. 125), afterwards more exactly by Chem. Gaz. [1852], 375). It is very soluble in alcohol, and crystallises olution in a network of slender needles. It melts at 51° C. (Luck), the at 45°, but after repeated crystallisation from alcohol and then from ether, 2·7° (Brazier). It gives off the odour of acrolein when heated. By saponi-th potash, it yields an acid, *Butyrolimnodic acid* (Bogbuttersäure), to which ned the improbable formula $C^{33}H^{33}O^4$; but according to Brazier, this acid ne composition as palmitic acid, $C^{32}H^{32}O^4$, or $C^{16}H^{32}O^2$, and melts at 53° C.

EAD COAL. See COAL.

RES. See IRON.

C ACID. $C^7H^{10}O^6 = C^7H^8O^4.H^2.O^2$.—An acid occurring in small quantity ea, together with quercitannic acid (Rochleder, Ann. Ch. Pharm. lxiii. prepare it, a decoction of black tea is precipitated at the boiling heat with lead; the filtered liquid is left to stand for twenty-four hours, and again separate a small sediment; the clear solution is mixed with a quantity of sufficient to neutralise the acid reaction; the yellow precipitate stirred up ute alcohol, and decomposed by sulphuretted hydrogen; and the filtrate left te in vacuo over oil of vitriol. The residue is dissolved in water, and the left to evaporate in vacuo, then dried at 100° C., this treatment being repeated s, and the residue finally left for three weeks in vacuo.

l when pulverised is of a pale yellow colour, like quercitannic acid. Melts into a mass which draws out into threads. It cakes together when exposed , even for a few minutes, and deliquesces very quickly. Colours ferric ate brown, without precipitation. Dissolves in all proportions in water and

distillation, it yields a light charcoal, and a distillate which smells of acetic blackens iron salts. The aqueous and alcoholic solutions decompose when in contact with the air. The acid is dibasic, the formula of its normal $C^7H^8O^4.M^2.O^2$.

The *barium-salt*, $C^7H^8Ba''O^6 + H^2O$, is obtained as a yellow precipitate b the solution of the acid in aqueous alcohol, with a slight excess of baryta-wat *normal lead-salt*, $C^7H^8Pb''O^6 + H^2O$, is obtained by mixing the alcoholic sol the acid, after concentration over potash in vacuo, with alcoholic acetate of lea ing the precipitate with alcohol, and drying at 100° C. It is white, with a grey. A *basic lead-salt*, $C^7H^8Pb''O^6.Pb''O$, is obtained by precipitating the solution of the acid with an ammoniacal solution of acetate of lead. It form yellow precipitate. (Rochleder.)

BOILING POINT. See HEAT.

BOLE. A massive mineral, having a perfectly conchoïdal fracture, a gli internal lustre, and a shining streak. Its colours are yellow-red, and browni It is translucent or opaque; soft, so as to be easily cut and to yield to the adheres to the tongue, has a greasy feel, and falls to pieces in water. Specifi 1·4 to 2. It may be polished. If it be immersed in water after it is dri asunder with a crackling noise. It is a hydrated silicate of aluminium, in aluminium is more or less replaced by iron (ferricum).

The following are analyses of bole:

	SiO^2	Al^2O^3	Fe^2O^3	CaO	MgO	K^2O	H^2O	
a. . . .	41·9	20·9	12·2	—	—	—	24·9	= 99·9 (Wac
b. . . .	42·00	24·04	10·03	0·52	0·43	—	24·03	= 101·05 (Löw
c. . . .	41·05	25·03	8·09	0·45	0·50	—	24·02	= 99·14 ,,
d. . . .	42·00	20·12	8·53	2·81	2·01	0·50	24·00	= 99·97 (Zelln
e. . . .	45·92	22·14	—	3·90	—	—	25·86	= 97·82 (Ram
f. . . .	47·03	18·46	6·36	1·00	—	0·90[*]	25·28	= 99·03 (Thom

a, from Säsebühl, near Göttingen; *b*, from Ettinghausen; *c*, from Cap de *d* from the Brechte Berg in Silesia. The composition of these specimens agr with the formula $4M^2O^3.9SiO^2.18H^2O$, which, by substituting $m = \frac{1}{3}M$, may to $m^6H^4Si^3O^{12} + 4aq$; *e*, from Stolpen in Saxony, is represented nearly by th $Ca''O.2Al^2O^3.4SiO^2 + 4aq = (Ca''al^{12}H^2)Si^4O^{16} + 3aq$; *f*, from the Giant's in Ireland, is nearly $M^4O^3.3SiO^2 + 6aq$, which may be reduced to (m^2H All these are formulæ of orthosilicates. (*Rammelsberg's Mineralchemie*, 57 ii. 252.)

BOLOGNIAN STONE. Lemery reports that an Italian shoemak Vincenzo Casciarolo, first discovered the phosphoric property of the Bologn It is the ponderous spar, or native sulphate of baryta. If it be first heated t then finely powdered, and made into a paste with mucilage, and this past into pieces a quarter of an inch thick, and dried in a moderate heat, be e the heat of a wind furnace, by placing them loose in the midst of the c pyrophorus will be obtained, which, after a few minutes' exposure to the s will give light enough in the dark to render the figures on the dial-plate o visible.

BOLETIC ACID. The name given by Braconnot to the acid existing *pseudo-igniarius*, since shown by Bolley and Dessaignes to be identical wit acid.

BOLETUS. A genus of mushroom, of which several species have been to chemical examination by Braconnot and Bouillon La Grange (Ann. C 272); and more recently by Bolley, (Ann. Ch. Pharm. lxxxvi. 44), and De (Compt. rend. xxxvii. 780).

The chief constituents of these fungi are extractive matter, nitrogenous the so-called fungin (*q. v.*), sometimes mannite, perhaps also fermentable certain organic acids, called *fungic* and *boletic* acids by Braconnot, but prob sisting, according to Dessaignes, of malic or fumaric acid. The ash contain lime, magnesia, phosphoric acid, &c. The species which have been exa *Boletus bovinus* (Crell's Chem. Ann. 1785, p. 280), *B. igniarius* (Ann. Chi *B. juglandis* (*ibid.* lxxxvii. 226), *B. laricis* (*ibid.* lxxx. 272), *B. sulphure* *viscidus* (Trommsdorff's N. Journ. ix. 240).

Boletus laricis, is used on the continent in medicine under the name of *a* is in white, light, friable pieces, the outside of which is like dark-coloured lea taste, at first sweetish, soon becomes bitter and acrid. Its infusion in water is sweet tasted, and reddens vegetable blues.

Boletus igniarius is found in most countries, and particularly in the of Scotland, on the trunks of old ash and other trees. The French and Ger pare it abundantly for making *tinder*, by boiling in water, drying, beating i it in a solution of nitre, and again drying it. In France it is called *amad* country *German tinder*. It has been recommended in surgery for stoppin rhage from wounds. It imparts to water a deep brown colour and an astring

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[*] Chloride of sodium.

ETIN. A resin of earthy aspect, found in the fossil fir-wood of Danish
and in the needles which fall from the growing trees. The fresh shoots
little of it; but it increases with the age of the needles, and is most abun-
umn and winter. It is prepared by treating with boiling alcohol the grey
ter found in hollow fossil fir-stems, and precipitating the foreign matters
te of lead. The solution on cooling deposits the boloretin as an earthy
h may be further purified by repeated solution in boiling alcohol, with
hydrochloric acid to precipitate lead. It is soluble in ether, but not in
l. Melts at 75°—79° C. Its composition is variable, but it appears always
the elements of oil of turpentine *plus* water. It does not, however, yield
ntine when treated with phosphoric anhydride. (Forchammer, Ann. Ch.
44.)

ITE A variety of olivin, Mg^2SiO^4, occurring in crystalline granules,
d through limestone at Bolton in Massachusetts. Colour ash-grey, wax-
ellowish-white, with vitreous lustre. Streak white. Transparent or trans-
ecific gravity 3·008 (Silliman); 3·21 (Brush). Hardness in unaltered
= 6 or rather greater (Brush). Cleavage distinct in one direction. In-
re the blowpipe; slightly attacked by hydrochloric acid. The following
ree nearly with the formula Mg^4SiO^4 or $2MgO.SiO^2$: *a* by J. L. Smith
J. [2] xviii. 372); *b* by G. J. Brush (*ibid.* xxvii. 395):

SiO^2	MgO	FeO	CaO	Al^2O^3	Loss by ignition	
42·31	51·16	2·77	. .	0·18	1·90	= 98·32
42·82	54·44	1·47	0·85	trace	0·76	= 100·43

y B. Silliman (Sill. Am. J. [2] viii. 15) and v. Hauer (Kenngott's
1854, 90) gave larger amounts of silica and alumina, and less magnesia;
eral appears to have been but imperfectly decomposed.

. A highly ferruginous clay from Sinope in Asia Minor, containing, ac-
Klaproth, 32·0 SiO^2, 26·5 Al^2O^3, 21·0 Fe^2O^3, 17·0 H^2O, and 1·5 NaCl.

(E. v. Bibra, Chemische Untersuchungen über die Knochen und Zähne,
infurt, 1844, p. 1—258, 289—385; E. Frémy, Ann. Ch. Phys. [3] xlvii.
also Traité de Chimie, par Pelouze et Frémy, 2nd edition, vi. 261; C. J.
, Physiological Chemistry, iii. 12, and Gmelin's Handbuch, viii. 429.)—
is of two kinds, *compact* and *spongy*. The long tubular bones of the
are formed mainly of the compact tissue, while the flat bones, as those of
d pelvis, and the short round bones, consist of an external compact layer,
mass of the more porous or spongy tissue. The outer surface of bones is
h a thin membrane (the *periosteum*), traversed by great numbers of nerves
ssels, while the inner surfaces of their cavities and channels are lined with
ner membrane. These tubes and cavities contain a fatty substance called
The substance of the bone itself exhibits a laminated structure, the indi-
rs being concentric with the tubes and channels containing the marrow.
s consist of an amorphous substance, intersected by cavities, from which
umerable intercommunicating channels.

bony tissue, distinguished from the external and internal membranes, the
d the various fluids contained in the channels and cavities above-mentioned,
entially of an organic substance, called *bone-cartilage*, or *ossein*, and an in-
stance, composed mainly of *tribasic phosphate of calcium*, $Ca^3P^2O^8$, together
r quantities of *phosphate of magnesium*, $Mg^3P^2O^8$, *carbonate of calcium*, and
calcium.

be incinerated without previously reducing it to powder, and washing out
and other extraneous fluids contained in its cavities, the ash will likewise
all quantities of *alkaline sulphates*, *carbonates*, and *chlorides*, and of *iron*,
re derived from the liquids just mentioned, and do not properly belong to
self.

-cartilage or ossein may be separated from the earthy matter by macerating
some time in dilute hydrochloric acid. The calcium-salts then gradually
e mass becomes translucent and soft, and ultimately the cartilage is left
ineral matter, and retaining the form of the bone. By boiling in water, it
d into gelatin and dissolves, forming a solution clouded by suspended fat
r tissue, and solidifying in a jelly on cooling. When freed from these ex-
atters by digestion in alcohol and in ether, it is found to have the same
l constitution as gelatin, as may be seen from the following table, in which
ition of bone-cartilage from various sources is compared with that of pure
glass).

Composition of Gelatin and Bone-cartilage.

	Carbon.	Hydrogen.	Nitrogen.	Oxygen.	
Gelatin:					
From Bone . . .	50·40	6·64	18·34	24·64	Mul
" " (fossil) . .	50·40	7·11	18·15	24·36	v. Bi
" Isinglass . . .	50·76	6·64	18·32	24·69	Mul
Bone-cartilage:					
From femur of Ox . .	50·13	7·07	18·45	24·35	v. B
" Pipa . .	50·45	7·08	18·21	24·24	,
" Rib of River Carp .	50·32	7·22	18·42	24·00	,
" Ox . . .	49·81	7·14	17·32	25·67	Frén
" Calf . . .	49·9	7·3	17·2	25·6	,
" Owl . . .	49·05	6·77			,

Bone-cartilage also contains sulphur, which v. Bibra estimates at 0·216 per c

The chief difference between bone-cartilage and gelatin is, that the latter d
easily and immediately in boiling water, whereas the former is insoluble in wat
it has been converted into gelatin, which requires long boiling.

According to Frémy, the bone-cartilage has likewise the same composition i
and in old animals. Fœtal bones, however, do not appear to yield gelatin whe
with water; or at all events, Schwann (Mikrosk. Unters. 1839, p. 3), could
tain that substance from the bones of a fœtal calf, nor Hoppel (Arch. f. patho
v. 174) from those of a rabbit, down to the last hours of intra-uterine life. I
bones, the cartilage is often found to be converted into true gelatin. The cart
diseased bones does not appear to differ from that of healthy bones (v. Bi
others). In the bones of certain water-birds, and in the spines of certain
Frémy found a substance resembling ossein in physical characters, and isome
it, but differing from it in not yielding gelatin when boiled with water.

Quantitative Analysis.—The bone is first reduced to fine powder by raspi
washed with water to remove soluble salts, &c., and digested with ether to
fatty matters. Care must however be taken not to continue the washing wit
too long, as by the prolonged action of water, small quantities of the phosp
calcium and magnesium are dissolved out, the quantity thus removed incre
the organic matter of the bone passes more and more into the state of putr
(Wöhler.)

The bone purified as above, is next incinerated in a muffle (p. 418), till it
quite white, then moistened with solution of carbonate of ammonium, to rest
carbonic acid that may have been driven off from the lime, and again hea
sufficiently to expel the excess of carbonate of ammonium. The difference
the weight of the dried bone before ignition, and that of the ash, gives the a
cartilage.

The analysis of the ash is made for the most part by the ordinary methods

The *carbonic acid* must be estimated by one of the methods given under
METRY (p. 117), first in the unignited bone-powder, and afterwards in the a
first gives the amount of carbonate of calcium in the bone, and from the d
of the two determinations, the quantity of lime which was in combination with
acids may be found. The amount of carbonate of calcium cannot be corre
mated by precipitating with carbonate of ammonium the lime which remains
tion after the phosphate of calcium has been precipitated by caustic ammon
adoption of this method in the earlier analyses, led to the incorrect conclu
the calcium-phosphate contained in bone-earth was $8Ca^2O.P^2O^5$, instead of 3C

The amount of *fluorine* in bones has seldom been determined quantitati
calcium really existing as fluoride being generally reckoned together with
bonate or phosphate. Marchand, however (J. pr. Chem. xxvii. 83), found in
thigh-bone 1 per cent., and Heintz (Wien, Akad. Ber. 1849, p. 51), found in
bone 2·05 per cent. fluoride of calcium. In fossil bones, the proportion of th
often much greater.

As bone-tissue is very hygroscopic, it is necessary, in comparing the qua
water which different bones retain, after drying in the air at ordinary temper
notice the indications of the barometer and thermometer before exposing the
the heat of the water-bath or oil-bath.

complete investigations that have been made of the composition of bone,
' v. Bibra and Frémy. The following table exhibits the percentage of
atter in human bones of various ages, as determined by v. Bibra.

e of Bone.	Percentage of Ash.	Name of Bone.	Percentage of Ash.
, 7 months:		*Woman*, 25 years:	
ibia, humerus	59·1 to 59·6	Femur, tibia, fibula, ulna,	
		os occipitis	68·4 to 68·8
us, 7 months	64·5 to 65·4	Humerus	69·25
ths:		Clavicule	67·51
	65·32	Rib	64·57
	64·07	Sternum	51·43
		Scapula	65·48
:		Vertebræ	54·25
	56·43	Os innominatum	59·97
	58·58		
	56·58	*Man*, between 25 and 30 yrs.	
	52·52	Femur, tibia, humerus,	
	56·51	ulna	68·0 to 69·4
	49·30	Os occipitis	68·73
	49·71	Rib	63·99
rs:		*Woman*, 78 years:	
	.67·80	Femur	66·81
	67·71		
ars:		*Man*, 58 years:	
	67·85	Femur, dense portion	68·53
	67·71	,, spongy portion	64·18

se results it appears: 1. That the proportion of inorganic matter in bone
youth than in age, although no regular gradation can be observed. 2. The
of inorganic matter is greater in compact than in spongy bone-tissue;
in the bones of the extremities than in those of the trunk; greatest of all
-bone. It appears, indeed, to be greatest in those bones which are most
ave to bear the greatest strain; this observation is corroborated by the
of the bones of birds (see below).

rent orders of mammiferous animals do not exhibit any essential differences
ortions of inorganic matter in their bones, the limits being 64 and 75 per
bones of birds contain on the average a larger proportion of inorganic
those of mammals, viz. 68·6 to 75·8 per cent.; those of reptiles rather
68·∂ per cent. The bones of fishes exhibit great variety in the proportion
matter which they contain, *e. g.* Bony fishes: *eel* 51·62 per cent.; *cod*
non 64·37; *perch* 59·40 per cent. Cartilaginous fishes: *Shark* 46 82 per
rey 1·66 per cent.

results agree for the most part with those of v. Bibra, excepting in the
of organic and inorganic matter in bones of different ages, which, according
do not exhibit in this respect any sensible variation. The bone of a fœtus
to yield the same quantity of ash as that of a woman 97 years of age, and
ny particles that make their appearance in the midst of the cartilaginous
h in the fœtus precedes the formation of true bone, were found to contain
uantity of mineral matter as the bone of an adult animal (see table, p. 621).
r brittleness of the bones in age is attributed by Frémy to the increase in
ion of the spongy tissue, the thickness of the hard and dense portion of the
nually diminishing as age advances.

analyses of the bones of animals belonging to different orders show, in
with those of v. Bibra, that the bones of mammifers exhibit the same
nposition as those of man, the bones of herbivorous quadrupeds, however,
ontaining a larger proportion of lime-salts than those of flesh-eaters. The
rds have nearly the same proportion of lime-salts as those of herbivorous
and those of reptiles nearly the same as those of carnivorous mammals.
of fishes exhibit great diversity of composition, those of bony fishes being
like those of manmifers, whereas those of cartilaginous fishes are rich in
tter, and contain but a small proportion of mineral salts.

Comparative Analyses of Bones belonging to different Orders of the Animal
(Frémy.)

Name of Bone.	Ash per cent.	Phosphate of Calcium.	Phosphate of Magnesium.
Male fœtus, 4 months; femur	61·7	60·2	
„ 6 months; „	62·8	60·2	
Female fœtus, „	63·0		
„ 7 months; humerus	62·8		
Girl, born alive; femur	64·8	60·8	
Boy, 18 months; „	64·6	61·5	
Woman, 22 years; scapula	63·3	60·0	
„ „ cranium	64·1	57·8	1·7
„ „ femur	64·6		
„ „ humerus	64·1		
Man; spongy part of femur	61·0		
„ dense „ „	65·0		
Man, 40 years; femur	64·2	56·9	1·3
Woman, 80 „ „	64·6	60·9	1·2
„ 81 „ „	64·5	58·1	1·2
„ 88 „ „	64·3	57·4	1·2
„ „ spongy part of femur	59·7	54·0	1·2
„ 97 „ femur	64·9	57·0	1·2
Egyptian mummy; femur	65·0	58·7	1·7
Daki; femur	64·0		
Kinkajou; femur	62·0		
Genet	70·2		
Bitch; femur	62·1	59·0	1·2
Young lioness; femur	64·7	60·0	1·5
Panther; femur	65·6		
Morse	63·1	53·9	1·5
Rabbit; femur	66·3	58·7	1·1
Guinea-pig	71·8		
Indian elephant	66·8	62·2	1·2
Java rhinoceros	65·3	60·0	2·3
Horse; femur	70·4		
Calf, still-born; spongy part of femur	61·5	60·5	1·2
„ „ dense „ „	64·4	59·4	1·7
„ 5 months; femur	69·1	61·2	1·2
Cow, full grown „	70·7		
„ old „	71·1		
„ „ „	71·3	62·5	2·7
Ox; humerus	70·4	61·4	1·7
„ „	70·2	62·4	1·7
Bull; femur	69·3	59·8	1·5
Lamb; „	67·7	60·7	1·5
Sheep; „	70·0	62·9	1·3
Goat; „	68·0	58·3	1·2
Cachalot „	62·9	51·9	0·5
Whale; spongy part	57·5		
Eagle	70·5	60·6	1·7
Vulture	66·2		
Owl (Grand Duke)	71·3	61·6	1·5
Ostrich; dense part	70·0		
„ spongy part	67·0		
Bustard	71·1		
Chicken	68·2	64·4	1·1
Turkey	67·7	63·8	1·2
Partridge	70·7	65·4	
Heron	70·6	62·5	1·5
Thrush	66·6	63·0	
Humming bird; bones of head	55·0		
„ „ „ limbs	59·0		

TABLE.—*continued.*

Name of Bone.	Ash per cent.	Phosphate of Calcium.	Phosphate of Magnesium.	Carbonate of Calcium.
	73·5	68·4	1·3	5·6
pace	64·3	58·0	1·2	
; carapace	64·0	56·0	1·2	10·7
utaneous bone	64·6	58·3	trace	9·7
	64·0	58·3	0·5	7·7
	67·5			
	61·3	55·1	1·3	7·0
	60·2			
	54·0			
	50·			
	61·4	58·1	1·1	4·7
	66·9	64·2	1·2	4·7
	57·0	56·1	trace	2·2
axillary with teeth	76·0			
ne of the skin	68·8			
	62·6			
ge	30·0	27·7	trace	4·3
	65·3	64·4	trace	1·3
ead with teeth	2·2			

Bones.—Bones are subject to several diseases, in nearly all of which
of inorganic matter is found to diminish. In *caries*, the calcareous por-
ne is destroyed, without alteration of the cartilage, the latter still yield-
when boiled with water. In a carious femur, v. Bibra found the
inorganic salts reduced to 38·3 per cent., and in a portion of astragalus,
e centre of the caries, it was only 18·5 per cent.—In *osteomalacia* and
oportion of mineral matter sometimes diminishes to such an extent, that
d under the weight of the body. Marchand found in the femur of a
72·20 per cent, cartilage, 7·20 fat, 14·78 phosphate of calcium, 3·0 car-
ium, 0·80 phosphate of magnesium, and 2·02 sulphate of calcium, chloride
n (and loss). In the *osteomalacia* of adults, the tribasic phosphate of
verted into ⅜-phosphate, $8Ca^2O.3P^2O^5$ (Weber), and the bones sometimes
acid. In this disease, and in the rachitis of children, the cartilage is
ered in character, so that it no longer yields gelatin when boiled with
osis is the formation of osseous tumours on the surface of bones; these
ise contain an excess of cartilage. *Sclerosis* is the formation of cartilage,
y of true bony tissue within the medullary cavities and canals of the
thus become denser and almost like ivory. Here also the organic matter
n excess, and the carbonate of calcium is increased in proportion to the
n *osteoporosis*, which is a dilatation of the medullary cavities, &c., either
ssive development of the medulla, or from the solvent action of fluids
he cavities, the mineral matter is also found to disappear more quickly
nic matter.

nes.—When a bone is exposed to the air or buried in the earth, the
gradually disappears, while the calcareous salts remain. In buried
sue likewise becomes incrusted with various substances derived from the
oil, so that fossil bones often contain considerable quantities of carbonate,
fluoride of calcium, silica, &c., according to the nature of the formation
y are embedded. The proportion of carbonate of calcium sometimes
per cent. The silica is in the form of quartz, that is, in the modifica-
insoluble in acids and in dilute alkalis. In some cases, the proportion
hosphate remains nearly the same as in the original bone, whereas in
eatly diminished. The proportion of phosphate of magnesium does not
it diminishes, however, to a certain extent when the phosphate of cal-
ced by carbonate of calcium or by siliceous compounds. Many fossil
ain a portion of their cartilage, which is sometimes also converted into

Analyses of Various Fossil bones. (Frémy.)

	Ash per cent.	Phosphate of Calcium.	Phosphate of Magnesium.	Carbonate of Calcium.	Silica and Fluoride of Calcium.
Ox, from the caves of Oreston; metatarsal bone, external portion having the aspect of wood	80·74	71·1	1·5	11·6	
Internal portion of the same, very friable	80·6	71·5	1·7	11·3	
Spongy portion of the same	84·2	63·3	1·2	5·2	17·2
Rhinoceros, from Sansan (Gers); vertebræ	83·4	59·0		41·3	3·6
Ribs of the same	83·1	66·8		27·5	1·4
Hyena, from the caves of Kirkdale; long bone	75·5	72·0	1·3	4·7	
Rhinoceros; dorsal vertebræ	69·5	25·7	0·4	57·5	8·5
" " humerus	73·0	32·4	0·4	64·0	6·2
" " teeth	90·4	65·2	0·7	13·8	14·5
Mastodon; tusk	90·4	56·5	0·7	13·1	24·3
Bear; dense part of bones	83·9	59·7	0·4	23·6	9·8
" spongy part	76·7	22·1	1·2	67·5	14·0
Anoplotherium; caudal vertebra	84·0	53·1	0·4	20·4	19·4
Tortoise; vertebræ	87·0	61·1	0·7	10·6	16·6

BONE-BLACK. *Animal black, Animal charcoal, Beinschwarz.*—A pro tained by heating bones to redness in close vessels. Large quantities of stink empyreumatic oil, and volatile alkaloïds, are then evolved, and there remains mass consisting of an intimate mixture of charcoal containing nitrogen, mineral matter of the bone, chiefly phosphate and carbonate of calcium. It the power of abstracting many solid substances from their solutions, and is very large scale as a decolorising agent in the refining of sugar. That it may this property in the highest degree, the preparation must be so conducted as the largest possible quantity of carbon in the product, and at the same time it very porous. The air must therefore be carefully excluded during the ignit the heat must be regulated so as not to cause the mass to cake together or agglutinated by the fusion of organic substances. The bones should be fres which have lost much of their organic matter by putrefaction, either in t underground, do not yield a sufficient quantity of charcoal. They should be comminuted and boiled to free them from fat, which would melt and yield a pact charcoal.

The yield of bone-black varies from 30 to 60 per cent. according to the com of the bones. The long cylindrical bones of the extremities are best adapted purpose; they yield about 60 per cent of bone-black, containing 1 to 1½ c 9 pts. phosphate of calcium. Ribs, skulls, and vertebræ yield a smaller and not of good quality: hence it is better to use them for the prepar gelatin.

The carbonisation of bones is performed either in iron cylinders, like those the distillation of coal, or in covered pots of cast-iron or crucible-ware, hea reverberatory furnace; the latter method yields the best charcoal, but the adopted when it is desired to collect the volatile products which are given o BONE-OIL.) (For details and figures of machinery, see *Ure's Dictionary Manufactures, and Mines*, i. 369; *Muspratt's Chemistry*, i. 315; *Handwörte Chem.* 2te Aufl. ii. 767).

Bone-black is extensively used both as a decolorising and deodorising likewise removes lime and its salts from their aqueous solutions, and is acc used for the purification of highly calcareous waters. In the refining of serves to free the syrup both from colouring matter and from lime. It dec many metallic salts, sometimes absorbing the oxides or metallic acids, so reducing them. It abstracts iodine, not only from solution, but even from It likewise removes bitter principles and organic alkaloïds from their soluti has been recommended as an antidote in case of poisoning by such substance

Bone-black which has been used for removing colouring matter and li syrup or other liquids, may be *revivified*, that is, restored to its original state following processes:—1. Treating it with acids to remove the lime.—2. Leav ferment or putrefy, in order to render soluble the organic substances which absorbed.—3. Washing.—4. Ignition. (For details, see the works above cite

Bone-black is sometimes used as a pigment; for which purpose it is made ater and finely pulverised in a colour-mill. The finest pigment of this *black*, which is obtained by the carbonisation of ivory.

-black is used as a manure, especially for cereal crops, being well adapted se, both by the phosphoric acid and the nitrogen which it contains. It is ous on soils which still retain a considerable quantity of decayed vege-

L. *Dippel's oil, Animal oil, Oleum animale Dippelii.*—This oil is obtained ity in the preparation of bone-black, by igniting charcoal in cylinders cts are obtained by the dry distillation of other animal substances. The *el's oil* known in Pharmacy was produced from stag's horn; but all the w met with in commerce, is obtained from bones in the manner above-It has been made the subject of a series of elaborate investigations by derson of Glasgow. (Transactions of the Royal Society of Edinburgh, art II. 247; xxi. Part I. 219, and Part IV. 571. Ann. Ch. Pharm. lxx. ; xciv. 358; cv. 335. Jahresber. f. Chem. 1847–8, p. 651; 1851, p. 488; 1867, p. 392.)

mainly a product of the decomposition of gelatinous tissue, inasmuch as d for the preparation of animal charcoal are boiled, before ignition, with ity of water, to deprive them of their fat (p. 624). The crude oil is r nearly black, and has a specific gravity of 0·970. It consists chiefly of volatile organic bases, together with smaller quantities of acids and carbons.

ng a large quantity of the crude oil to fractional distillation, the first $\frac{1}{3}$ of consists of about equal parts of a yellow oil and a watery liquid holding ulphide, cyanide, and carbonate of ammonium, together with small very volatile organic bases. On supersaturating this watery liquid with d, boiling for a while, then distilling with slaked lime, and immersing h in the watery distillate, ammonia is given off with brisk effervescence, uantity of oily bases separates on the surface of the potash-solution.

ing $\frac{2}{3}$ of the distillate consists of oily bases of various degrees of volatility. em (together with the small portion of oily bases separated from the just mentioned) with excess of dilute sulphuric acid, setting the mixture days, and frequently shaking it, then separating the strongly acid liquid ion of oil still unacted on, and boiling it for some time in a still, an alka-sses over containing *pyrrhol*, C^4H^5N, a weak base first noticed by Runge xxxi. 65) in bone-oil and in coal-tar, and distinguished by the property of deep purple-red colour to fir wood moistened with hydrochloric acid.

ning acid liquid, after cooling, is mixed with excess of slaked lime and the distillate is treated with solid caustic potash, which separates a ly bases, while the watery liquid retains in solution *ammonia* and *methy-* are given off on simply distilling the liquid, and may be condensed in loric acid.

ing to fractional distillation the mixture of oily bases separated by the nber of bases are obtained from 65° to 100° C. belonging to the series . ethylamine C^2H^7N, tritylamine C^3H^9N, tetrylamine $C^4H^{11}N$, and amy-H; and above 115° C. another series of bases are given off belonging to the -⁵N, and isomeric with phenylamine and its homologues, viz.:

Pyridine, C^5H^5N, boiling at 116·7° C.
Picoline, C^6H^7N, „ „ 135
Lutidine, C^7H^9N, „ „ 154·5
Collidine, $C^8H^{11}N$, „ „ 180

sic portion of bone-oil yields by repeated rectification, a liquid boiling at h, when exposed to a freezing mixture, separates into two distinct layers. boiling at a higher temperature do not exhibit this property. They con-and probably also homologues thereof, also *alcohol-radicles*, and *nitro-unds* which are decomposed by sodium.

RFFITE. A variety of hydrous dichroïte (ii. 422).

TE. *Borazite. Borate of Magnesia.*—A mineral occurring in crystals gypsum and anhydrite at Lüneberg in Hanover, Segeberg in Hol-neville, La Meurthe, in France. The crystals are monometric; cubes, dodecahedrons or tetrahedrons, generally hemihedral combinations with ber of faces. Cleavage octahedral in traces. Specific gravity = 2·974. 7. Lustre vitreous, inclining to adamantine. Colour white, inclining to and green. Streak white. Subtransparent to subtranslucent. Fracture neven. Pyro-electric, even when massive. (Dana, ii. 393.)

as formerly regarded as a borate of magnesium, $3Mg''O.B^2O^3$, containing a small quantity of iron; but recent analyses have shown that it likewise contains The mean results are as follows:

MgO	FeO	B^2O^3	Cl	H^2O	
30·67	1·62	62·55	7·96	0·75	(Potyka.)
30·48	1·38	—	8·50	—	(Siewert and Geis

If now the ferrous oxide be reckoned as magnesia (FeO : MgO = 72 : analyses give respectively 31·57 and 31·25 magnesia; and the results agre with the formula $Mg''Cl^2.2(3Mg''O.4B^2O^3)$, which requires 31·35 per cen 62·50 B^2O^3, and 7·94 Cl. (Rammelsberg's Mineralchemie, p. 254.)

BORAX. Acid borate of sodium. See Borates, under Boron, Oxide o

BORIDES. Compounds of boron with metals. See Boron.

BORNEENE. *Valerene.* $C^{10}H^{16}$.—A liquid hydrocarbon, isomeric wi turpentine, secreted by the *Dryabalanops camphora*, and holding in solutio substance, borneol, or camphor of Borneo. It is also obtained from essenti valerian, by submitting that oil to fractional distillation, and heating the first of the distillate with hydrate of potassium, which takes up valerol, while passes as a distillate. Solid Bornean camphor distilled with phosphoric a also yields a liquid hydrocarbon having the composition $C^{10}H^{16}$. (See Valerian,

Borneene is lighter than water, almost insoluble in that liquid, and smell of turpentine. It turns the plane of polarisation of a luminous ray to the left strongly than oil of turpentine. The product obtained from oil of valerian 160° C., that from Borneo camphor at 165°. Vapour-density 4·60. It absorl chloric acid gas, forming a cyrstalline compound. It appears to oxidise whe badly closed vessels, and when immersed in water, especially in presence of appears to be converted into borneol (Gerhardt, Traité, iii. 628, 641 Dryabalanops.)

Borneene from Madder Fusel-oil.—The fusel-oil contained in the alcohol by the distillation of madder-sugar, yields liquid products when distilled at tures rising to 230° C., while at higher temperatures lævo-rotatory borneol The former, by digestion with caustic potash, then with chloride of calcium, and fractional distillation, yields a liquid which boils at 160° C., contains 88·23 carbon and 11·81 hydrogen, has a vapour-density = 4·85, and is therefore borneene. Lævo-rotatory borneol (*vid. inf.*) distilled with phosphoric anhyd yields a liquid which appears to be borneene. (Jeanjean, Ann. Ch. Pharm.

BORNEOL. *Borneol Alcohol, Solid Camphor of Borneo.* $C^{10}H^{18}O$.—T stance is extracted from the *Dryabalanops camphora*, being found in cavitie trunks of old trees. It is also found in small quantity in moist oil of valeria probably formed by hydration of borneene.

According to Pierlot (Ann. Ch. Phys. ix. 291) the crystals found in oil of are not borneol, but valerian-camphor, $C^{12}H^{20}$.

Borneol is produced artificially by heating common camphor with alcoholic its formation being attended, either with evolution of oxygen:

$$\underset{\text{Camphor.}}{C^{10}H^{16}O} + H^2O = \underset{\text{Borneol.}}{C^{10}H^{18}O} + O;$$

or with simultaneous production of camphic acid:

$$\underset{\text{Camphor.}}{2C^{10}H^{16}O} + H^2O = \underset{\text{Borneol.}}{C^{10}H^{18}O} + \underset{\text{Camphic acid.}}{C^{10}H^{16}O^2}.$$

The action takes place slowly at 100° C., more quickly at higher temperatures tubes. (Berthelot, Ann. Ch. Phys. [3] lvi. 78.)

Borneol forms small transparent, colourless, very friable crystals or crystalli ments, having an odour like that of common camphor and of pepper, and a hot taste. The crystals appear to be regular six-sided prisms belonging to the he system. Their alcoholic solution possesses dextro-rotatory power, like that of camphor. Dextro-rotatory power of natural borneol = 33·40 (Biot), of th cial = 44·9°. Borneol is lighter than water, and insoluble in that liquid, b soluble in alcohol and ether. Melts at 198° C., and boils at 212°, distilli out alteration. Gently heated with phosphoric anhydride, it yields borneene, Boiled with strong nitric acid, it gives off H^2, and is converted into common c $C^{10}H^{16}O$. With hydrochloric acid it unites without liquefying: the compoun stroyed by heat.

Lævo-rotatory Borneol.—This substance, which is isomeric with ordina neol, but differs from it in possessing equal but opposite rotatory power, is foun alcohol produced by the fermentation of madder-sugar, and is obtained by co vhich crystallise out on standing, or during fractional distillation. It forms aminæ, or a white powder smelling like pepper and common camphor. It aringly in water, and when thrown on the surface of water, spins like mphor. It dissolves easily in acetic acid, alcohol, and ether. Boiling converts it into lævo-rotatory camphor. Distilled with phosphoric anhyoride of zinc, it yields a hydrocarbon resembling oil of lemon or bergamot. Ann. Ch. Pharm. ci. 94.)

TE. Syn. with Erubescite and with Tetradymite.

ALCITE. Native borate of calcium (p. 643).

. *Atomic Weight* 11. *Symbol* B.—This element occurs in nature as *boric acid*, and in a few minerals, viz. *native borax* or *tincal*, *boracite*, *hydroolite*, and *botryolite*, and in small quantities in *schorl*, *apyrite*, *axinite*, *te*. It never occurs in the free state. Homberg, in 1702, first obtained om borax, and anhydrous boric acid was decomposed by Gay-Lussac and 1808, and immediately afterwards, by Sir H. Davy, into oxygen and boron. y be obtained in three different states, viz. *amorphous*, *graphitoïdal*, and . (Wöhler and Deville, Ann. Ch. Phys. [3] lii. 63.)

phous Boron.—This is the form in which boron was first obtained. and Thénard prepared it by igniting boric anhydride (vitrefied boric acid) ith an equal weight of potassium in small pieces, then boiling the fused ery dilute hydrochloric acid, washing with water, and drying. This pro- however, but a small product, as it is difficult to deprive the boric acid of , and the remaining quantity oxidises part of the potassium, with violent comsing part of the mass to be projected. According to R. D. Thomson (Phil. 419), this inconvenience may be obviated by drying the boric anhydride ly as possible, mixing it in the state of coarse powder, with twice its otassium, freed as completely as possible from the crust of hydrate which lheres to it, and gradually heating the mixture to redness in a glass tube . Wöhler and Deville mix 60 grammes of sodium in small pieces with es of finely powdered boric anhydride in an iron crucible, and cover with about 30 grammes of pulverised and previously ignited chloride of he crucible is then quickly heated to redness, whereupon a violent reaction , and the whole becomes liquid. It is carefully stirred with an iron rod free sodium or unfused chloride of sodium can be seen, then carefully water acidulated with hydrochloric acid, and washed and dried as above. rphous boron is very apt to run through the filter when washed with pure best to wash with water containing sal-ammoniac, and then remove that ns of alcohol.—Another mode of preparing amorphous boron is that of vhich consists in decomposing perfectly dry borofluoride of potassium by vith an equal weight of metallic potassium in an iron tube closed at both mixture is first heated merely to the melting point of potassium, then well an iron rod, and afterwards heated to redness. The decomposition takes ut explosion, and the boron is afterwards separated from the fluoride of with which it is mixed, by digestion and washing with water containing ac, the latter being finally removed by alcohol. If too little potassium has to produce complete decomposition, the washing is rendered difficult by ing borofluoride of potassium, which has but little solubility. Amorphous o formed, together with the other two varieties, in the modes of preparation be described.

us boron is a dark-brown or greenish-brown powder, opaque, destitute of mell, and stains the fingers strongly. It is a non-conductor of electricity. r in gases with which it does not unite, it may be raised even to a white t melting, or subliming, or undergoing any alteration, excepting that it dense that it sinks rapidly in oil of vitriol. In the unignited state, it disvery slight extent, in pure water, imparting its colour; in water containing ts it is insoluble, and indeed such substances precipitate it from its aqueous

us boron does not oxidise in the air or in oxygen gas at ordinary temperat about 300° C. it burns in the air with a reddish light, and in oxygen gas ng brightness; the combustion is in both cases attended with vivid emisrks, and in oxygen gas, according to Berzelius, a faint greenish flame is obe product is boric oxide or anhydride, B^2O^3, the only known oxide of boron, on the surface of the boron and partly protects it from further action. eric air, according to Wöhler and Deville, a small quantity of nitride of rmed at the same time.

Amorphous boron does not decompose water, even at the boiling heat, but
decomposes strong sulphuric acid when heated with it, and nitric acid, e
but slightly concentrated, in the cold, the product in each case being boric a
red heat, it decomposes the carbonates, sulphites, sulphates, nitrites, and n
the alkali-metals, an alkaline borate being formed, and carbon, sulphur, or
set free. The decomposition is sometimes attended with incandescence an
case of nitre, with explosion. It also decomposes many metallic oxides at a
forming a borate, if the oxide is in excess. Heated with hydrate of pota
eliminates hydrogen, and forms borate of potassium. It likewise redu
metallic chlorides and sulphides, *e.g.* chloride of lead, chloride of silver, an
of lead at a red heat, chloride of boron being formed and escaping as gas
and Deville). It precipitates metallic gold from a solution of the chlorid
strongly ignited in a current of nitrogen gas, it is converted into white nitride
Heated nearly to redness in a current of nitric oxide gas, it burns brilliantl
boric anhydride and nitride of boron. It does not decompose nitrous oxide.
and Deville).

By ignition with aluminium, amorphous boron may be converted into the
modifications, which remain behind on dissolving out the aluminium by hy
acid.

Graphitoïdal Boron.—This variety of boron is obtained:—1. By passi
chloride of boron for some time over aluminium in the state of fusion.* T
takes up but a small quantity of boron; but on breaking it, the boron is fou
fractured surface in copper-coloured crystalline laminæ, like graphite in
they may be separated by dissolving out the aluminium with hydrochlor
2. By heating 8 pts. of borofluoride of potassium and 5 pts. of aluminium w
of 9 pts. chloride of potassium and 7 pts. chloride of sodium to the meltin
silver, in a porcelain crucible, and treating the half fused metallic mass fou
midst of the slag, first with hydrochloric then with hydrofluoric acid. Bor
mains in small blackish-grey crystalline scales.—3. By fusing a mixture of 1
anhydride, 10 pts. fluor-spar, and 2 pts. aluminium; or by fusing aluminium
anhydride, or better with fused borax and cryolite, and a flux of chloride of
and chloride of sodium. A large excess of aluminium, however, is require
but a small quantity of boron.

Graphitoïdal boron has a semi-metallic lustre, like graphite or crysta
oxide, but with a distinct tinge of copper-red. When well crystallised, it form
sided tablets belonging to the hexagonal system; but it is more generally o
a reddish-grey, micaceous powder composed of fine crystalline laminæ. It i
opaque. When heated to redness in the air, it does not burn or undergo an
alteration. It does not dissolve in acids or in alkalis, but appears to be
into boric acid by the long-continued action of nitric acid. (Wöhler and

Adamantine or *Diamond Boron.*—This is not, strictly speaking,
pure boron; at least, as hitherto obtained, it always contains carbon and
aluminium. To prepare it, 80 grammes of aluminium in lumps are heate
grammes of boric anhydride to a temperature at which nickel fuses rea
mixture is introduced into a crucible of compact charcoal fitted with
cover and placed within a hessian or black-lead crucible, the intermediate s
filled with charcoal-powder, and the cover fastened on with refractory lutin
whole is exposed for five or six hours to the strongest heat of an air-furnac
tall chimney and fed with a mixture of coke and coal. On breaking th
after cooling, two layers are found, one glassy, consisting of boric anhy
alumina, the other a metallic iron-grey mass of aluminium, penetrated
with crystalline boron. The aluminium is dissolved out by strong soda-le
hot hydrochloric acid, and the residue is treated with a hot mixture of
hydrofluoric acid, to remove silicium. The crystals of diamond boron thus
are still mixed with graphitoïdal boron and crystalline laminæ of alumina;
being light, may be separated by levigation; the latter only by careful
selection.

Adamantine boron forms quadratic octahedrons, in which the principal
the secondary axes as 0·577 : 1. The crystals vary in colour, from a sc
ceptible honey-yellow to deep garnet-red; sometimes they are so deeply col
bably by amorphous boron, that they appear black. In lustre and refracti
they are nearly equal to the diamond. Their specific gravity is 2·68. Th
tremely hard, always sufficiently so to scratch corundum with facility,
crystals are nearly as hard as diamond itself. The hardest are obtained by
exposing aluminium to the action of boric anhydride at a temperature high
cause the anhydride to volatilise very quickly.

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* It has lately been shown to be merely a boride of aluminium. (See SUPPLEMENT, p

boron does not fuse, even at the heat of the oxyhydrogen blowpipe, and action of oxygen even when very strongly heated; but it is slightly temperature at which the diamond burns, a film of boric anhydride ied, which stops further oxidation. Heated on platinum-foil before the ms a fusible boride of platinum. It is not attacked by acids at any t when heated to redness with acid sulphate of potassium, it is con c acid. It is not attacked by a strong boiling solution of caustic soda, ssolved by hydrate or carbonate of sodium at a red heat. Nitre does ct upon it at any temperature.

, as already observed, with oxygen and with nitrogen, also with ne, fluorine, and sulphur. With metals it does not, for the most part, but borides of palladium and platinum are known. The platinum ry fusible, so that boron, in either of its modifications, if ignited on efore the blowpipe, instantly perforates the platinum. (Wöhler and

ts combinations appears to be triatomic; the chloride being BCl^3, the hydrate (boric acid) H^3BO^3, &c.

ROMIDE OF. BBr^3.—Discovered by Poggiale in 1846 (Compt. rend. first obtained pure by Wöhler and Deville (Ann. Ch. Phys. [3] lii. uced by the action of bromine on amorphous boron, or on boric anhy e of charcoal. The best way of preparing it is to pass bromine-vapour orphous boron, previously well dried in a current of hydrogen; then ict for some time with metallic mercury, to remove excess of bromine

of boron is a colourless mobile liquid, of specific gravity 2·69, vola at ordinary temperatures, in colourless, pungent vapours, and boiling ary atmospheric pressure, at 90° C. Vapour-density (referred to air), 8·78; by calculation (2 vol.) = 8·7. It fumes in moist air, and is in osed by water, with formation of boric and hydrobromic acids. With a, it forms a white pulverulent substance, which is converted by water d borate of ammonium: possibly thus:

$$BBr^3.4NH^3 + 2H^2O = 3NH^4Br + NH^4BO^2.$$

HLORIDE OF. BCl^3.—First prepared by Berzelius (Pogg. Ann. rds by Dumas (Ann. Ch. Phys. [2] xxxi. 436; xxxiii. 376), more ated by Wöhler and Deville (*ibid.* [3] lii. 88). It is formed by the ion of chlorine and boron, which takes place at ordinary temperatures, heat; also by heating boron in hydrochloric acid gas, or a mixture of and charcoal in chlorine gas, and by the action of boron at a red heat nercury, lead, or silver.

t, amorphous boron, loosely packed in a glass tube, is first freed from ssing dry hydrogen over it at a gentle heat; the tube is then left open ds, to allow the hydrogen to escape; after which, dry chlorine gas is the tube, the action being assisted if necessary, by gently heating the stion furnace. Combination then takes place, attended with evolution at; and the vapours of chloride of boron are passed through a caout g-tube into a Y-shaped tube, the two upper arms of which are sur ce and salt, while the lower arm conveys the condensed liquid into a below. The product may be freed from excess of chlorine by digestion A small quantity of oxychloride of boron is generally formed at the he action of a little air or moisture left in the apparatus; but it con oler part of the combustion-tube. The chloride of boron may be freed chlorine by digestion with mercury.

apour of chloride of boron is mixed with hydrogen, as when it is pro ing boron in hydrochloric acid gas, or with carbonic oxide, as when e action of chlorine on a hot mixture of boric anhydride and charcoal, lt to condense; indeed, chloride of boron was originally regarded as a temperatures, until Wöhler and Deville obtained it in a state of purity above described.

e of boron is a colourless, mobile, strongly refracting liquid, having a of 1·35 at 17° C. (? 7°); it expands very perceptibly by a rise of 1° or re. It boils at 17° C. Vapour-density, by experiment = 4·06—4·08; 2 vol.) = 4·07. It fumes in damp air, and is quickly decomposed by boric and hydrochloric acids. With alcohol, it forms, with great rise hydrochloric acid and borate of ethyl: similar reactions with methylic hols.

Ammonio-chloride of Boron, $3NH^3.2BCl^3$, is formed, with great evolution
when dry ammonia-gas is passed over chloride of boron. It is a white, fine
talline powder, which sublimes unaltered when heated alone, though not so
sal-ammoniac. It does not fume in the air, but is decomposed by water, yieldi
acid, chloride of ammonium, and hydrochloric acid:

$$2BCl^3.3NH^3 + 6H^2O = 2H^3BO^3 + 3NH^4Cl + 3HCl.$$

When the vapour of this compound, mixed with ammonia-gas, is passed th
red-hot tube, nitride of boron is produced.

BORON, CHLOROCYANIDE OF. See CYANOGEN, CHLORIDE OF.

BORON, DETECTION AND ESTIMATION OF. Boron almost
occurs in the form of boric acid, and therefore the reactions by which it is
are best considered in detail in connection with that acid (see page 639). W
acid is in the free state, it is easily recognised by the green colour which it im
flame, especially to an alcohol flame, and by its peculiar action on turmeric p
the acid is in combination with a base, the compound must first be decompose
state of powder by sulphuric acid, and the boric acid extracted with alcohol.
borates not decomposible by sulphuric acid, must be fused with potash, a
digested with alcohol and sulphuric acid. Another method of detecting b
minerals is to mix the pulverised substance with 4 pts. of a flux contain
pounded fluorspar and 4½ pts. acid sulphate of potassium, made into a past
little water, and heat the mixture on a platinum wire in the inner blowpip
As the mass melts, fluoride of boron is given off, and imparts a yellow-green
the outer flame. If the quantity of boron present is small, this appearance lasts
a few seconds, ceasing, in fact, as soon as the fluoride of boron is completely vo

The green colour imparted to flame is a very delicate test for boron.
applying it, however, care must be taken to ensure the complete absence of c
the salts of this metal impart a very bright green colour to flame. Certain
compounds also colour flames green, as when hydrochloric acid is dropped
alcohol flame; but the green colour thus produced has a decided bluish ting
distinguishes it from that produced by boron. Lastly, phosphates moisten
sulphuric acid, also give a faint green colour to the outer blowpipe flame.

Quantitative Estimation.—The exact estimation of boron presents con
difficulties, as all borates are more or less soluble in water or in alcohol, and b
cannot be heated without loss in contact with water. The best mode of di
mation, originally proposed by Berzelius, and perfected by Stromeyer (
Pharm. c. 82), is to precipitate the boron as borofluoride of potassium, which
insoluble in alcohol of a certain strength. This mode of precipitation, ho
directly applicable only when the boron exists in solution as borate of potassi
other bases present must first be separated. Borates of the alkaline-earth
earth-metals, or heavy metals, are fused with carbonate of potassium; and the
digested in water, which takes up nothing but borate of potassium, except p
trace of magnesia. Borate of sodium is treated with alcohol and sulphuric a
alcoholic liquid filtered from the sulphate of sodium, is mixed with excess o
free from silicic and carbonic acids; and the alcohol is evaporated. The alkali
of potassium obtained in either case, is now to be saturated with pure hyd
acid, and the liquid evaporated to dryness in a silver or platinum vessel;
saline mass is macerated with a solution of acetate of potassium (1 pt. of th
4 pts. water); the undissolved borofluoride of potassium is collected on a weigh
supported on a gutta-percha funnel, and washed, first with the solution of a
potassium, which removes chloride, phosphate, and sulphate of potassium.
sodium-salts though slowly, and afterwards with alcohol of 84 per cent. Trall
cific gravity 0·8526), then dried at 100° C. and weighed. 100 parts of the bor
correspond to 27·78 boric anhydride, or 9·06 boron.

To ascertain whether the precipitate is pure, it is dissolved in boiling wate
leaves behind any traces of magnesia that may be present, and the solution is
with ammonia, which precipitates silica if present: the precipitate may then be
first with acetate of potassium, then with alcohol, and its weight ascertained.

The quantity of free boric acid in an aqueous or alcoholic solution, cannot b
mined by evaporation to dryness, because a considerable quantity of the acid
with the aqueous or alcoholic vapours: even the presence of excess of lea
baryta, or basic phosphate of sodium, does not completely prevent this eva
Ammonia prevents the volatilisation to a greater extent than either of these su
but it does not quite prevent loss. The only exact mode of determining boric
evaporation, is to supersaturate the liquid with a known weight of pure fused c
of sodium (about 2 pts. of the carbonate to 1 pt. of acid supposed to be present
evaporate to dryness, and ignite the residue in a covered crucible. The a

anhydride in the residue is then to be determined by the method given under
ISTRY (p. 149), and deducting this, together with the known weight of soda
d in the carbonate added, from the total weight of the residue, the remainder
antity of boric anhydride present.

in borates may be estimated *indirectly* in several ways. The best method is
t a weighed quantity of the pulverised compound in a capacious platinum
with hydrofluoric acid, then gradually add strong sulphuric acid, and heat
ure, gently at first, and afterwards to redness, till the excess of sulphuric acid
ed. The boron is then completely driven off as fluoride, and the bases remain
rm of sulphates. If only one base is present, its quantity is easily calculated
weight of the residue. If two bases are present, *e.g.* potash and soda, the
of sulphuric acid in the residue must be ascertained; the quantities of the two
y then be found by the method given under INDIRECT ANALYSIS (p. 224). If
n two bases are present, they must be separated by the usual methods. The
f the bases deducted from that of the original substance, gives the amount of
hydride.

d of driving off the boron as fluoride, it may be volatilised as borate of ethyl,
ing the pulverised borate with strong sulphuric acid and alcohol. Or the
d set free by the action of sulphuric acid, may be dissolved out by alcohol
rated by filtration; but this last method is applicable only when the resulting
s are completely insoluble in alcohol.

acid combined with potash or with soda, may be estimated **volumetrically**
s of a standard solution of sulphuric acid. The solution is coloured with
of litmus, and the sulphuric acid is cautiously added from a burette, till the
colour first produced by the liberation of the boric acid, changes to the bright
h indicates the presence of free sulphuric acid: this takes place as soon as
tity of sulphuric acid (H^2SO^4) amounts to 1 at. for 2 at. of potash or soda
r NaHO). Hence the amount of the base is found, and this deducted from
weight of the dry salt, gives the boric acid.

ration of Boron from other Elements.—When boric acid is in com-
with several bases, it is best to estimate the amount of these bases at once,
rmine the boric acid (or anhydride) by difference. From the metals of the
p, *copper*, for example, boron is easily separated by sulphuretted hydrogen; from
d others of the second group, by sulphide of ammonium. From *barium* it is
d by sulphuric acid; from *strontium* and *calcium*, by sulphuric acid and alcohol;
gnesium, by ammonia and phosphate of sodium: the precipitate in this last
erally contains a small quantity of boric acid.

eparation of boric acid from all these bases may likewise be effected by fusion
aline carbonates; in the case of magnesia, carbonate of potassium must be
cause soda forms with magnesia an insoluble compound.

uric acid is easily separated from boric acid by precipitation with chloride of
hydrochloric, *hydrobromic*, and *hydriodic* acids, by adding nitrate of silver to
tion acidulated with nitric acid; *phosphoric acid*, by ammonia and sulphate
esium.

stimation of boron in presence of *fluorine* is difficult. Metallic borofluorides
lysed by heating them with sulphuric acid, whereby fluoride of boron and
oric acid are driven off, and the metal remains as sulphate, from the weight
h its quantity may be determined, and hence the amount of the boron and
together. If the compound contains water of crystallisation, it must be de-
d by mixing the compound with 6 pts. of oxide of lead, covering the mixture
rt with a layer of oxide of lead, and exposing it to a heat short of redness.
of weight gives the water.

mixture of a borate with a fluoride, it is impossible to determine either the
r the fluorine exactly. By dissolving the compound in excess of nitric acid,
ing excess of carbonate of calcium, the fluorine is precipitated as fluoride of
but not completely, probably because a borofluoride is formed.

estimation of boron in *silicates* is likewise difficult. If the silicate is decom-
y acids, like datolite or botryolite, it is finely pulverised, heated in a corked
th hydrochloric acid, at last nearly to boiling; the thick jelly is then diluted
ter and filtered; the filtrate supersaturated with ammonia, which separates
; oxalic acid is added to precipitate lime; and the filtrate, which now contains
but boric acid in combination with ammonia, is evaporated in a platinum
over the water-bath, with frequent addition of ammonia. The dry residue is
dually heated to redness in a covered platinum crucible, whereupon boric anhy-
mains mixed with a little silica. The boric anhydride is afterwards dissolved
water, and the residual silica weighed. The result is not quite exact, as a little
id goes off even in presence of excess of ammonia, but the loss is not considerable.

In silicates not decomposible by acids, boron is estimated by heating the pulv mineral, first with hydrofluoric and then with sulphuric acid, whereby the bor silicium are expelled as fluorides. The bases then remain as sulphates, and ar termined by the ordinary methods. In another portion of the mineral, the sili determined by fusion with a mixture of the carbonates of potassium and so treatment of the residue with hydrochloric acid, evaporation to dryness, digesti the residue in acidulated water, filtration, and washing,—whereupon the silica re on the filter in a state of purity, and may be ignited and weighed. The bases an silica having been thus determined, the boric anhydride is found by difference result being of course affected by all the errors in the several determinat (H. Rose, Analyt. Chem. ii. 734.)

The estimation of boron in *organic compounds*, is generally effected by mixin compound with ammonia in a capacious platinum crucible, then evaporating igniting the residue. This method, according to Ebelmen, always involves a loss least 2 per cent. of boron, and that loss may even amount to 4 per cent. A b method might perhaps be to heat the compound with nitric acid in a sealed tube cording to Carius's method (p. 247): the boron would thereby be converted boric acid, and might then be estimated by any of the methods above given.

Atomic Weight of Boron.—The earlier experiments of Gay-Lussac and Thé Davy, and Berzelius, in which the atomic weight of boron was estimated by the an of oxygen absorbed in its combustion, did not lead to concordant results. Berz afterwards determined its value from the amount of water in crystallised borax, w in three experiments, he found to be 47·1 per cent. Now supposing the formula o salt to be $Na^2O.2B^2O^3 + 10H^2O$, and that the atomic weight of sodium is 23 result makes the atomic weight of boron equal to 11. Experiments by Deville ported by **Dumas** (Ann. Ch. Phys. [3] lv. 129), on the proportion of chlorin chloride of boron, gave, on the supposition that the formula of the chloride is the two results $B = 11{\cdot}0$ and $B = 10{\cdot}6$. Similar experiments with bromide of b BBr^3, gave $B = 11{\cdot}0$. This number appears therefore to have the greatest weig evidence in its favour. If the formula of chloride of boron were BCl^6, the at weight of boron would be 7·3.

BORON, FLUORIDE OF. BF^3.—Discovered by Gay-Lussac and Thénar 1810. It is obtained: 1. By the action of boric anhydride on fluoride of calcin high temperatures:

$$3Ca''F^2 + 7B^2O^3 = 3(Ca''O.2B^2O^3) + 2BF^3.$$

An intimate mixture of 2 pts. fluorspar and 1 pt. vitreous boric anhydride is duced into a gun-barrel closed at one end, and heated to whiteness in a furnace good draught, and the gas which escapes is received over mercury: borate of ca then remains behind.—2. By the action of hydrofluoric acid on boric acid or dride, viz. by heating a mixture of 1 pt. boric anhydride (or 2 pts. fused borax) 2 pts. fluor spar, with 12 pts. oil of vitriol, in a glass vessel:

$$3Ca''F^2 + B^2O^3 + 3H^2SO^4 = 3Ca''SO^4 + 3H^2O + 2BF^3.$$

This method is easier than the former, but the gas which it yields is not quite as it contains a little fluoride of silicium, resulting from decomposition of the moreover part of the fluoride of boron is converted by the water into boric and h fluoric acids.

Fluoride of boron is a colourless gas, of pungent suffocating odour, like th fluoride of silicium. Specific gravity = 2·37 (**Davy**); 2·31 (**Dumas**); and b culation:

$$\frac{11 + 3 \,.\, 18{\cdot}7}{2} \times 0{\cdot}0693 = 2{\cdot}29$$

It reddens litmus, fumes in damp air, and chars organic bodies like sulphuric It does not corrode glass. It is not decomposed by a red heat, or by the el spark.

Water absorbs about 700 times its volume of this gas, with great evolution of and increase of bulk, forming an oily liquid of specific gravity 1·77, which boiled, gives off $\frac{1}{5}$ of the dissolved gas, and leaves a residue consisting of B^2O^3 or $2BF^3.3H^2O$, which may be distilled without alteration. Water incompletely rated with fluoride of boron, deposits boric acid on cooling, or after standing for time, while fluoride of boron and hydrogen $HF.BF^3$, remains in solution.

Strong *sulphuric acid* absorbs 50 times its volume of gaseous fluoride of boron, ing a viscid liquid, which deposits boric acid when mixed with water.

Potassium, *sodium*, and the *alkaline earth-metals*, heated in fluoride of boro come covered with a blackish crust, which bursts at a red heat, the metal then b

at incandescence, and forming a metallic borofluoride, with separation of
on does not act upon the gas, even at a bright-red heat. *Quick lime* absorbs
boron readily when heated, forming a fusible mixture of fluoride and borate

monia gas forms with an equal volume of fluoride of boron, a white, opaque,
ound, $NH^3.BF^3$, which volatilises undecomposed, and is converted by water
uoride and borate of ammonium. By the further action of ammonia on this
liquid compounds, $2NH^3.BF^3$, and $3NH^3.BF^3$, are formed; when exposed to
heated, they give off ammonia and reproduce the solid compound.
ng to Kuhlmann, fluoride of boron unites with nitric oxide, nitrous acid,
f nitrogen, and nitric acid.

oric Acid. $HBO^2.3HF$.—This compound, discovered by Gay-Lussac and
is obtained by saturating water with gaseous fluoride of boron, the vessel
ed with ice, and the gas-delivery-tube made to dip under mercury below the
otherwise the rapid absorption would cause the liquid to run back into the
vessel. The saturated solution has a specific gravity of 1·77, and is nearly
oric anhydride, $B^2O^3.6HF$, or hydrate of boric fluoride, $2BF^3.3H^2O$ (Gmelin's
uate of boric acid, *$BO^3.3HF$*, Handbook, ii. 363). On heating it, one-fifth
orbed fluoride of boron goes off, and there remains a liquid of specific gravity
ch is fluoboric acid, $H^2O.B^2O^3.6HF$, or $HBO^2.3HF$.
er mode of preparing this acid is to dissolve boric acid or anhydride in hy-
acid contained in a platinum crucible externally cooled, avoiding an excess
cid, then evaporate over the water-bath, gently boil the remaining liquid
red crucible, till the vapours form a thick fume in the air, and leave the
ool over sulphuric acid. It may also be obtained by fusing an intimate
10 pts. fluorspar and 8½ crystallised borax, pulverising the fused mass, and
t with 16⅔ pts. strong sulphuric acid. The product thus obtained generally
little silica derived from the distillation-vessel.
ic acid is an oily liquid, like oil of vitriol, fumes in the air, boils at a tem-
bove 100° C., and distils without alteration. It is highly caustic, chars
dies, and converts alcohol into ether. By dilution with water, it is decom-
fourth of the boric acid being separated, and a solution of hydrofluoboric acid
:

$$4(HBO^2.3HF) - HBO^2 = 3HBF^4 + 6H^2O.$$

ic acid forms salts, having the general formula $MBO^2.3MF$. They are pro-
the direct action of the acid on the bases, or by dissolving the corresponding
d fluorides in the proper proportions, and leaving the solution to evaporate.
f them have been examined.
dium-salt, $NaBO^2.3NaF + \frac{1}{2}$ aq, crystallises in small rectangular prisms,
ir terminal faces obliquely truncated; they have an alkaline reaction, give
ater at 40° C., and melt at a higher temperature. The fused salt, if quickly
idifies to a clear glass; but by slow cooling, it becomes turbid, from separa-
oride of sodium, which remains undissolved on treating the mass with cold
ereas boiling water dissolves the whole, reproducing the original salt.
fluoborate of sodium, $NaHB^2O^4.6NaF + 10$ aq, is produced by slowly eva-
solution of 1 at. borax and 6 at. fluoride of sodium. It crystallises in small
r four-sided prisms, which become turbid at 40° C. from loss of water, and
e the preceding when melted and slowly cooled. (Handw. d. Chem. 2te Aufl.
.)

fluoboric Acid. $HBF^4 = BF^3.HF$.—Obtained by passing gaseous fluoride
nto water, till the liquid is strongly acid, and exposing it to a low tempe-
oric acid then separates, and hydrofluoboric acid remains in solution:

$$4BF^3 + 2H^2O = 3BHF^4 + HBO^2.$$

ar solution is obtained by dissolving crystallised boric acid to saturation in
y strong hydrofluoric acid artificially cooled.
uoboric acid is known only in the state of dilute solution. It is decomposed
tration, yielding hydrofluoric and fluoboric acids:

$$BHF^4 + 2H^2O = HF + HBO^2.3HF.$$

ute state, it does not attack glass; but if it be concentrated in a glass vessel,
becomes corroded from separation of hydrofluoric acid; if, however, boric
dded during the concentration, so as to form fluoboric acid, no corrosion of
akes place.
luorides.—These salts, whose composition is expressed by the general
$MF.BF^3$ and $M''F^2.2BF^3$, are formed by the action of gaseous fluoride of

boron or aqueous fluoboric acid on metallic fluorides; by the action of metalli on hydrofluoboric acid; or by dissolving a metallic fluoride, together with b in aqueous hydrofluoric acid; sometimes also by merely bringing a fluoride i with boric acid, the liquid then becoming alkaline if previously neutral, or eve

Most borofluorides are soluble in water, and are obtained in the crystall by evaporating their aqueous solutions. At a red heat, they are resolved into of boron and metallic fluoride. Distilled with sulphuric acid, they give off fluoride of boron and aqueous hydrofluoboric acid. They are for the most decomposed by heating with alkalis or alkaline carbonates.

Borofluoride of Aluminium, crystallises by slow evaporation from a solution o of aluminium in excess of hydrofluoboric acid; the crystals dissolve in wa when free acid is present. On mixing a solution of chloride of aluminium wi fluoride of sodium, a basic borofluoride of aluminium is precipitated, which, heat, is resolved into fluoboric acid and borate of aluminium.

Borofluoride of Ammonium, $NH^4F.BF^3$, is obtained by subliming a mixtu potassium-salt with sal-ammoniac, or more easily by dissolving boric acid in fluoride of ammonium, ammonia being then evolved:

$$4NH^4F + H^3BO^3 = NH^4F.BF^3 + 3H^2O + 3NH^3.$$

It crystallises by evaporation in six-sided prisms with dihedral summits; readily in water, somewhat less in alcohol; reddens litmus; does not attac dissolves in aqueous ammonia, and crystallises out unaltered; sublimes when

Borofluoride of Barium, $Ba''F^2.2BF^3.H^2O$.—Prepared by saturating hydrofluob with carbonate of barium, avoiding an excess, otherwise fluoride of barium a acid are produced. Crystallises from a warm solution in long needles; by slo ration in a warm atmosphere, in smooth rectangular prisms, often arranged like common salt. Has an acid reaction; tastes like barium-salts in gener solves readily in water; deliquesces in moist air. Alcohol decomposes it, disso acid salt, and separating a white powder. The crystals effloresce at 40° C. and pose at a higher temperature.

Borofluoride of Calcium.—A solution of carbonate of calcium in hydrofluo deposits on evaporation, a gelatinous mass, which dries up to a white powder, litmus, and is decomposed by water, with separation of a basic salt.

Borofluoride of Copper, $Cu''B^2F^8$.—Light blue needles obtained by decompo barium-salt with sulphate of copper, and evaporating the filtrate.

Borofluoride of Lead, $Pb''B^2F^8$.—Prepared like the barium-salt, and crystalli difficulty by spontaneous evaporation, in four-sided prisms; from the solutio rated to a syrup, in long prisms. Has a sweetish taste, with sour astringent af Partially dissolved by water and by alcohol. Heated with oxide of lead, it is yield an easily fusible oxyborofluoride, whose aqueous solution is rendered tu the carbonic acid in the air.

Borofluoride of Lithium, $LiBF^4$.—Prepared like the copper-salt, and separ evaporation at 40° C. in large prismatic crystals, which have a rather bitter a taste, and deliquesce in the air, sparingly soluble rhombohedral crystals th rating, which have not been further examined.

Borofluoride of Magnesium. — Easily soluble; crystallises in large prisms bitter.

Borofluoride of Potassium KBF^4. — Formed like the ammonium-salt, by boric acid to aqueous fluoride of potassium. It may be prepared by dissolvi (124 pts.), of crystallised boric acid, and 1 at. (138 pts.) carbonate of potassium i of hydrofluoric acid, or by adding a soluble potassium-salt to hydrofluoric then separates as a transparent gelatinous precipitate, which appears irides reflected light while suspended in the liquid, and dries up to a white pow dissolves in 70 pts. of cold, and in a smaller quantity of hot water, and cr from the solution in anhydrous, shining, six-sided prisms. It has a bitteri and does not redden litmus. Alkalis do not dissolve it more readily th water. Ammonia does not alter it, unless the solution contains silica, in whic precipitate is formed. It dissolves in boiling alcohol. When heated, it fir then gives off fluoride of boron, and if not quite dry, likewise fluoboric acid; a prolonged exposure to a strong heat, leaves fluoride of potassium. Strong s acid decomposes it but slowly, even with the aid of heat.

Borofluoride of Sodium, $NaBF^4$, forms short four-sided rectangular pris soluble in water, less in alcohol; has a rather bitter and acid taste, and litmus. The crystals are anhydrous, melt below a red heat, but require str prolonged ignition to decompose them completely into fluoride of boron and of sodium.

Borofluoride of Yttrium dissolves only in water containing free aci

in crystals by dissolving yttria in excess of hydrofluoboric acid, and
g.

ride of Zinc, $Zn''B^2F^8$.—Zinc dissolves in hydrofluoboric acid with evolution
on. The solution evaporated to a syrup solidifies at low temperatures to a
nt mass.

N, IODIDE OF. Not yet obtained in the pure state. Iodine and boron
eated together, form a product which appears to be an oxyiodide (Wöhler
lle). Boron does not decompose iodide of silver, even at temperatures
melting point of the metal.
ng to Inglis, a mixture of boric anhydride and charcoal heated in iodine-
elds a yellow sublimate, which has not been examined.

N, NITRIDE OF. BN.—This compound was discovered by Balmain
g. [3] xxi. 170: xxii. 467; xxiii. 71; xxiv. 191), who at first regarded it as
uniting with metals and forming compounds analogous to the cyanides;
ards found that all these supposed metallic compounds were one and the
tance, viz. nitride of boron without any appreciable amount of metal.
usion has been confirmed by Marignac (Ann. Ch. Pharm. lxxix. 247).
btained this substance by heating boric anhydride with cyanide of potassium
of zinc, or with cyanide of mercury and sulphur. It has since been more
investigated by Wöhler (Ann. Ch. Pharm. lxxiv. 70), who prepares it by
bright redness in a porcelain or platinum crucible a mixture of 2 pts
mmoniac and 1 pt. pure anhydrous borax:

$$Na^2O.2B^2O^3 + 2NH^4Cl = 2BN + 2NaCl + B^2O^3 + 4H^2O.$$

ct is a white porous mass, which is pulverised and washed with water to
n chloride of sodium and boric anhydride, the final washings being made
g water acidulated with hydrochloric acid. The boric anhydride is, how-
mpletely incorporated with the nitride of boron, that it cannot be wholly
y washing. A purer product might perhaps be obtained by using neutral
odium instead of borax, in which case, no excess of boric anhydride would
:

$$Na^2O.B^2O^3 + 2NH^4Cl = 2BN + 2NaCl + 4H^2O.$$

formerly prepared nitride of boron by igniting anhydrous borax with ferro-
potassium. It is likewise produced when amorphous boron is heated to
in a stream of pure nitrogen; more easily, but with simultaneous formation
hydride, when boron is ignited in a current of air, or of nitrous or nitric
also, with incandescence and evolution of hydrogen, when boron is heated
ammonia. (Wöhler and Deville, Ann. Ch. Pharm. cv. 69.)
of boron is a white amorphous powder, tasteless, inodorous, soft to the
luble in water, infusible, and non-volatile. If very pure, it exhibits when
he edge of a flame, a brilliant greenish-white phosphorescence, undergoing
e time a slow oxidation. Heated in an alcohol-flame fed with oxygen gas,
pidly, with faint greenish-white flame, giving off fumes of boric anhydride.
educes the oxides of copper and lead, giving off nitrous fumes. Heated in a
aqueous vapour, it yields ammonia and boric anhydride:

$$2BN + 3H^2O = B^2O^3 + 2NH^3.$$

and the greater number of acids, even in the state of concentrated solution,
tion on nitride of boron; strong sulphuric acid, however, with the aid of heat,
converts it into ammonia and boric acid. Fuming hydrofluoric acid con-
to borofluoride of ammonium. Nitride of boron undergoes no alteration
ed in a current of chlorine. When fused with hydrate of potassium, it
large quantity of ammonia. With anhydrous carbonate of potassium, it
te and cyanate of potassium:

$$BN + 2(K^2CO^3) = KBO^2 + KCNO.$$

t decompose carbonic anhydride, even at the highest temperatures.

N, OXIDE OF. *Boric Oxide* or *Anhydride*. *Anhydrous boric acid*, B^2O^3.
e only known oxide of boron. It is formed when boron burns in oxygen gas,
or in nitric oxide gas (p. 626); but it is more easily obtained by exposing
which is its hydrate, to a strong heat. Water then goes off, and the an-
elts to a viscid mass, which, on cooling, solidifies to a colourless brittle glass
oric or *boracic acid*) of specific gravity 1·83. It cracks spontaneously in
d the formation of each crack is attended with a flash of light (Dumas).
tly fixed in the fire when alone, but in presence of water, and still more of

alcohol, it volatilises to a considerable amount. It is perfectly inodorou
slightly bitter but not sour taste; dissolves readily in water, forming boric aci
alcohol. The alcoholic solution burns with a green flame; so likewise does a
of boric anhydride and sulphur.

Potassium heated with boric anhydride decomposes it with visible con
sodium decomposes it quietly. It is not decomposed by phosphorus-vapour at a
or by charcoal even at a white heat (Gmelin). It unites with metallic oxi
fused with them, forming borates. From its fixity in the fire, it is capable
posing at high temperatures, not only carbonates, but likewise nitrates, sulph
indeed the salts of all acids which are more volatile than itself.

Boric Acid.

Oxide of Boron and Hydrogen. Boracic Acid. Sal sedativum Homb
narcoticum vitrioli. H^3BO^3 or $3H^2O.B^2O^3$.—This acid is formed by the ox
boron in presence of water, *e. g.* by the action of nitric acid or aqua-regia
also by dissolving the anhydride in water. It occurs native in the free stat
volcanic districts, especially in Tuscany, where it issues from the earth tog
vapour of water, and is found, either as an efflorescence in the neighbourho
springs, or dissolved in the water of small lakes or lagoons (*Laguni*), f
the vapours themselves. It is also found in small quantity in several miner
viz. in the boiling spring of Wiesbaden; in the iodine-water of Kranken
Fölz, and of the Kaiser spring in Aachen; in the mother-liquor of the salt
Bex (Baup), and in several hepatic waters. A few borates are also found
(p. 626), especially borax, the acid borate of sodium, which exists in th
certain lakes in Central Asia.

Preparation.—On the small scale, boric acid is prepared from borax.
crystallised borax are dissolved in 12 pts. of boiling water, and to the filtere
is added 1 pt. of strong sulphuric acid, or so much hydrochloric acid that t
strongly reddens litmus. The greater part of the boric acid then separates
in crystalline scales, and a larger quantity may be obtained by evaporating th
liquor. The crystals retain a certain portion of sulphuric or hydrochloric a
the latter they are easily freed by gentle heating and recrystallisation.
them free from sulphuric acid, they must be fused in a platinum crucible,
recrystallised.

Formerly all the boric acid of commerce was obtained from borax. It
separated in 1702 by Homberg, who prepared it by heating borax with calcin
sulphate in closed vessels, whereby sodio-ferric sulphate was formed, and b
was carried over with the watery vapour which escaped. Boric acid may also b
by the decomposition of other native borates, *e.g.* borate of magnesium
and borate of calcium and sodium (*boronatrocalcite*).

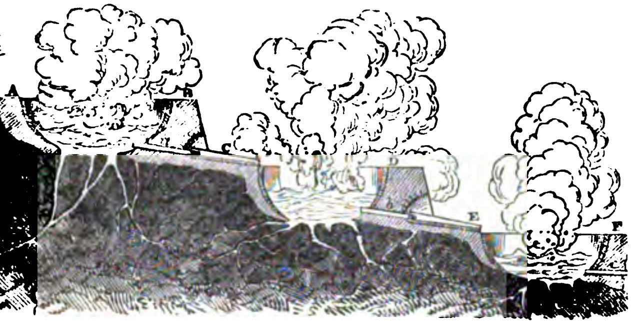
Preparation on the large scale (Payen, Précis de Chimie industrielle
1859, i. 423).—All the boric acid of commerce is now obtained from the
district of Tuscany, where it is discharged from the interior of the earth by
jets of vapour called *suffioni*, often rising in thick columns to a considerab
The entire surface of the district, consisting of chalk and marl, is subject to
shocks caused by subterranean agencies; and columns of boiling water are f
projected into the air, which is also strongly impregnated with sulphurette
gen. These vapours contain, besides aqueous vapour, carbonic acid, s
acid, nitrogen, hydrogen, a gaseous hydrocarbon, and sometimes oxygen
with a small quantity of boric acid and much solid matter carried up mec
Ch. Deville and F. Leblanc found, in the vapour of one of the suffioni, abo
cent. CO^2, 4 per cent. H^2S, and 5 per cent. nitrogen and combustible gases.

The vapours which issue from the clefts do not contain any appreciable q
boric acid, but where pools are formed round the suffioni, either artificia
natural condensation of the vapours, the water soon becomes charged with b
Probably the greater part of the acid is first deposited on the sides of
before it reaches the surface, and when water penetrates into them, the a
solved and thrown up in the state of solution.

To obtain the boric acid, the suffioni are surrounded with basins of coarse
glazed on the inside, and large enough to enclose two or three suffioni. A seri
basins are constructed on the hill-side, and into the uppermost A B (*fig.* 106),
of a spring is turned, and after remaining there 24 hours, during which time
in a state of constant agitation by the subterranean vapour, it is made to pas
the tube *a*, into a second basin C D, where it likewise remains 24 hours, and
a second quantity of boric acid; thence it passes successively by the pipes
the third and fourth basins, the liquid discharged from a lower basin b
tinually supplied from the one above it. When the liquid has thus trav

these lagoons, it is found to have taken up about 0·5 per cent. of boric
have a specific gravity of 1·007 to 1·010.

Fig. 106.



last lagoon G, H (*figs.* 107, 108), the solution passes into a large vessel I,
co, where it deposits a quantity of mud, and afterwards into two smaller
, K, for further clarification. From K it passes into a series of leaden
in section in *fig.* 106 and in plan in *fig.* 107, placed one above the other
r of terraces on a wooden scaffold. Formerly these pans were heated by wood
is was found too costly, the district being nearly bare of wood; the evapo-
performed by means of the subterranean heat, one or more of the jets

Fig. 107.

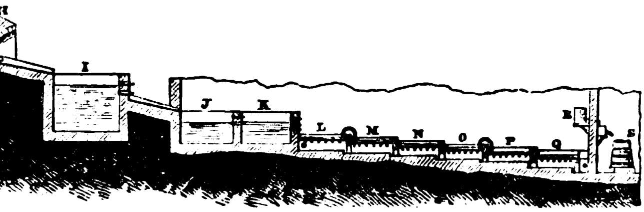
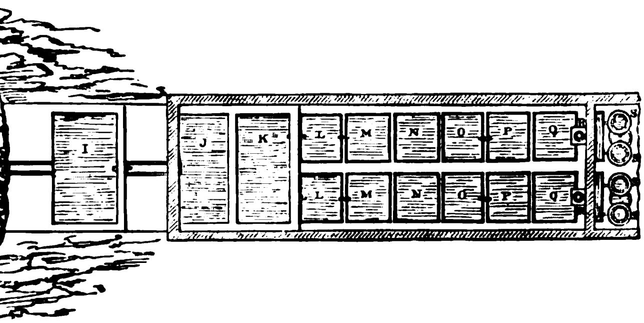


Fig. 108.

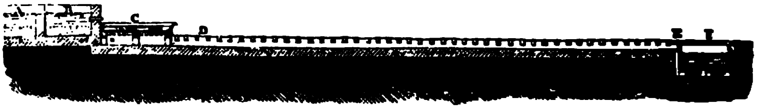


losed in pipes being conducted between the foundation and the bottom of
he steam enters beneath the bottom pans, and is carried regularly upwards,
lowest pans, which contain the most concentrated liquid, become most
s mode of utilising the subterranean heat was introduced in 1817, by
rel, at that time the proprietor of all the lagoons, and had the effect of
n unprofitable branch of industry into one which is now the source of
lth.

rm of apparatus for the evaporation is shown in *fig.* 109. The liquid,
the vascos A, B, passes into a shallow boiler C, from which it is made to

run slowly over an inclined sheet of lead, D, E, about 160 feet long, and having corrugations on its surface, which form a series of channels. The liquid, in running over this surface, gradually evaporates, and the solution ultimately reaches the basin F, at a degree of concentration fit for crystallisation. Heat is supplied by the vapour of one of the suffioni introduced under the basin F, and carried up under the sheet of lead to C. This method of evaporation is easier than the preceding, and does not introduce so much lead into the solution.

Fig. 109.



The solution of boric acid concentrated by either of these methods, is next mixed with the mother-liquor of a preceding operation, and poured through the funnels R into the round crystallising tubs S, S, (*figs.* 107 108, 110) which are made of wood lined with lead. The crystals are taken out after a while, and placed to drain in baskets, J, on the top of the tubs, the mother-liquor running into receivers placed under the floor.

Fig. 110.

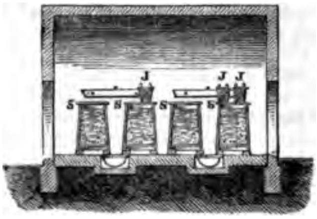
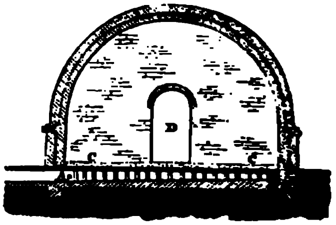


Fig. 111.



Lastly, the crystals, while still moist, are spread out on the floor C C, of the drying chamber D (*fig.* 111). This chamber has a double floor, and is heated by steam entering at A, and circulating between the two floors.

The product thus obtained is far from pure, not containing more than about 76 per cent. of boric acid. The composition of the crude acid, according to the analyses of Wittstein and Payen, is as follows:

	Wittstein.	Payen.
Crystallised boric acid	76·5	74 to 84°
Ferric sulphate	0·4	
Sulphate of aluminium	0·3	
Sulphate of calcium	1·0	2·4 to 1·2 [*]
Sulphate of magnesium	2·6	14·0 to 8
Sulphate of ammonium	8·5	
Sulphate of sodium	0·9	
Sulphate of potassium	0·4	
Sulphate of manganese	trace	
Chloride of ammonium	0·2	2·6 to 1·0
Silica	1·2	
Sulphuric acid	1·3	
Water	6·6	7·0 to 5·8 [†]

Schmidt found, in crude boric acid from Tuscany, 80 per cent. boric acid and 20 per cent. impurities, chiefly the sulphates of ammonium and magnesium. Richardson and Browell found in some samples, not more than 36 to 42 per cent. of the pure acid [? crystallised or anhydrous]. The experience of the French manufacturers of borax seems to show that the impurities in boric acid from Tuscany become greater year by year, which may perhaps be due to the increasing disintegration of the earthy strata by the aqueous and acid vapours.

Of the origin of the vapours by which the boric acid is brought to the surface, nothing certain is known. Dumas has suggested that they may proceed from a deep-seated bed of sulphide of boron, with which the water of lakes, or of the sea, comes in contact, thereby producing boric and sulphydric acids. Part of the boric acid may thus be supposed to act upon the carbonates of calcium and magnesium in the soil, converting

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[*] Including sand, clay, &c.

[†] Including organic matter.

es, and setting free carbonic anhydride. The sulphuretted hydrogen
by the air, yields free sulphur, which is deposited on the edges of
ne ammonia and organic matter are derived from the water, and the
s from the water and the earthy strata, through which the vapours
Bolley supposes that the boric acid and ammonia may result from
ution of sal-ammoniac at a boiling-heat, on borates contained in the
ording to Warington, the formation of these products may be ascribed to
ter on nitride of boron. There is, however, nothing positive to indi-
of the particular compound or compounds of boron, to which the elimi-
ric acid is really due.

Boric acid crystallises from water in white, translucent, nacreous, six-
omewhat unctuous to the touch; it is inodorous, and has a faint,
ther bitterish, cooling taste. Specific gravity = 1·48. It dissolves in
ter at 18° C.; in 14·9 parts at 25°, in 10·7 parts at 50°, in 4·7 parts
2·97 parts at 100°. (Brandes and Firnhaber.) It is still more
ol and in volatile oils.

solves in warm concentrated sulphuric, nitric, or hydrochloric acid, but
e most part on cooling, or on addition of water. Its solubility in water
addition of tartaric acid, tartrate of potassium, Rochelle salt, racemic
racemates.

ed acid heated to 80°—100° C., gives off 21·8 per cent. water, that is to
antity which it contains, leaving $H^6B^4O^9$ or $3H^2O.2B^2O^3$ (according to
gives off nearly all its water at 100° C.); by prolonged heating to
ived of 2 at. water more, leaving $H^2B^4O^7 = H^2O.2B^2O^3$, and at a
he remaining water goes off, leaving the anhydride B^2O^3, as a fused
ich solidifies to a fissured glass on cooling (p. 635).

cold saturated aqueous solution of boric acid colours litmus-tincture
int of port wine), like carbonic acid, but a hot saturated solution
red. Turmeric paper moistened with the alcoholic solution of boric
reddish-brown colour, quite different from that produced by alkalis,
distinct only after drying: it is intensified by acids, especially by
lphuric, nitric, and tartaric acids, and turned black by alkalis.

solution of boric acid burns with a beautiful green-edged flame, a
is quite characteristic of boron, provided copper and certain chlorine-
absent. This green colour is not produced, however, when the acid is
with an alkali or other base; and its production is partly prevented
of chloride of sodium or calcium, and even by small quantities of tar-
m or Rochelle salt (doubtless because these salts are partly decomposed
d, and neutralise it), also by free tartaric acid or phosphoric acid. In
cases, the green colour appears on addition of sulphuric acid, or of a
antity of hydrochloric acid (H. Rose, Pogg. Ann. cii. 545). It must
wever, that a green flame, though of a more bluish tint, is produced
ric acid itself is dropped into burning alcohol. (See p. 630.)
ions with metallic salts see p. 640.

Berzelius, Traité, vol. i—iv. Gm. vol. i—vi. Handw. d. Chem.
303. H. Rose, Pogg. Ann. ix. 76; lxxxvi. 581; lxxxvii. 1, 470 and
299, 482; xci. 452. Wöhler, *ibid.* xxviii. 525. Rammelsberg,
Ebelmen, Ann Ch. Phys. [3] xxxiii. 34. Herapath, Ann. Ch.
54. Bolley, *ibid.* lxviii. 122. Laurent, Ann. Ch. Phys. [2] lxvii.
Compt. rend. xxxix. 192; xlv. 411. Bloxam, Chem. Soc. Qu. J.
3.)—Boric acid forms salts in which the proportion of anhydrous base
rous acid (B^2O^3), or of metal to boron, ranges between the limits 9 : 1 and
hich contain equal proportions of base and acid are usually regarded
ormal borates, the rest as basic or acid. The following proportions
ved:

Basic.	Neutral.	Acid.
$M^2O.B^2O^3$	$M^2O.B^2O^3$	$2M^2O.3B^2O^3$
$M^2O.B^2O^3$		$M^2O.2B^2O^3$
$M^2O.2B^2O^3$		$M^2O.3B^2O^3$
$3M^2O.B^2O^3$		$M^2O.4B^2O^3$
$M^2O.2B^2O^3$		$M^2O.5B^2O^3$
$2M^2O.B^2O^3$		$M^2O.6B^2O^3$
$3M^2O.2B^2O^3$		

o-called acid borates, however, contain several atoms of water; and if
art of this water be regarded as basic, we shall find that nearly all
arranged in two classes, orthoborates and metaborates (so called

from their analogy with the ortho- and meta-phosphates and silicates), the comp
of which may be represented by the following general formulæ, the symbol M d
either a single monatomic metal, or two, or three such metals, including hydro

$$\text{Orthoborates } 3M^2O.B^2O^3\text{, or } M^3BO^3 = \left.\begin{matrix}M^3\\B'''\end{matrix}\right\}O^3$$

$$\text{Metaborates } n(M^2O.B^2O^3)\text{, or } M^nB^nO^{2n} = \left.\begin{matrix}M^n\\(B''')^n\end{matrix}\right\}O^{2n}$$

The latter formula, which, when $n = 1$, becomes that of the so-called
borates, MBO^2, includes the greater number of the salts of boric acid. Neve
it appears probable that boric acid is essentially tribasic, and that the bora
taining 3 at. metal to 1 at. boron are its normal salts (hence called orthob
for crystallised boric acid contains H^3BO^3; and there are boric ethers contain
alcohol-radicle to 1 at. boron, whereas none are known of the form RBO^2.
it appears from the experiments of Bloxam, that boric acid, when ignited with
hydrates, mostly drives out 3 at. of water, forming a trimetallic borate, except in
of hydrate of potassium, in which the water is retained with peculiar force ; a
heated to bright redness with carbonates, it expels a quantity of carbonic a
approaching more nearly to 3 atoms as the base is weaker, that limit being
reached in the case of strontia. (See Borates of Barium, Lithium, Potass
Sodium.) There appear also to be a few borates intermediate in composition
ortho- and metaborates, viz. $M^4B^2O^5 = M^3BO^3.MBO^2$.

Borates containing more than 3 at. metal to 1 at. boron may be regarded
pounds of orthoborates with metallic oxides or hydrates (see Borates of Alu
and those anhydrous borates which contain more than 1 at. boron to 1 at. me
be regarded as metaborates combined with boric anhydride ; *e.g.* anhydrou
$Na^2O.2B^2O^3 = 2NaBO^2.B^2O^3$.

Borates are formed by the action of boric acid on metallic oxides or the
either in the wet or in the dry way. At high temperatures, boric acid or a
decomposes carbonates, sulphates, chlorides, and indeed the salts of all volati
Acid borates, **borax** for example, take up additional quantities of base when
with metallic oxides, and likewise decompose the salts of volatile acids. In
way, on the contrary, boric acid acts as a very weak acid, being separated
combinations completely by most acids, and partially, under certain circumstances
carbonic acid, sulphydric acid, and water. In concentrated solution, however, i
poses carbonates, especially at the boiling heat; also soluble sulphides and pre
sulphide of manganese. It has but little power of neutralising the alkaline
of the stronger bases, so that even the solutions of many of the polyacid
exhibit a strong alkaline reaction to litmus, which is not neutralised till the
combined with 5 or 6 atoms of boric acid, and even then the liquid does no
an acid reaction.

The borates of the alkali-metals dissolve readily in water, but are precipi
alcohol. All other borates dissolve but sparingly soluble in water ; but none are
insoluble. The sparingly soluble borates may be obtained by precipitation.
these precipitates are soluble in excess of the soluble metallic salt from which t
been formed, but not in excess of alkaline borate ; *e.g.* the precipitate formed
dissolves in solution of chloride of barium, but not of **borax** : they are often
soluble in chloride of ammonium and in free boric acid. The sparingly solubl
are easily decomposed by water, especially when boiled with it, the boric ac
sometimes almost completely removed. Hence it is very difficult to obtain th
in the pure state. H. Rose, in his elaborate investigation of the borates, pu
precipitates as completely as possible by repeated pressure between paper
washing, and afterwards estimated the quantity of foreign salts still attache
precipitate. The soluble borates are likewise decomposed by water. If
solution of **borax** be mixed with slightly reddened tincture of litmus, the liqui
its faint red colour, but on dilution with water becomes distinctly blue,
indeed like a dilute solution of free alkali **mixed** with boric acid. Neutral
alkali-metal exhibit a similar reaction.

When a solution of an alkaline borate coloured with tincture of litmus is
mixed with sulphuric acid, the liquid exhibits a wine-red colour till all the
saturated with sulphuric acid ; after that, a single drop of sulphuric acid pro
bright red colour.

Solutions of alkaline borates absorb carbonic and sulphydric acid gases ;
monia from its salts when boiled with them, like dilute alkalis ; their dilute
also react like alkalis with mercury and silver-salts, and with many organic s
(See Borax, p. 648.)

The soluble borates, both neutral and acid, give white precipitates with so

of barium, chloride of *calcium*, *alum*, sulphate of *zinc* and nitrate of *lead*; red-
h sulphate of *cobalt*; greenish with sulphate of *nickel*; yellowish with *ferric* sul-
the cold, brown on boiling. These precipitates dissolve easily in sal-ammoniac;
hey have been produced by an acid borate of alkali-metal, borax for example,
olve pretty readily in an excess of the salt from which they have been obtained;
cipitates formed by neutral borates of alkali-metal in the same solutions ex-
nilar characters, excepting that they are less soluble in excess of the earth-
heavy metal salt.

on of borax or of monoborate of sodium, does not precipitate sulphate of
um in the cold; but on heating, a precipitate forms which disappears again on
completely; if formed by the acid borate; nearly, if by the neutral borate.
tral and acid borates of alkali-metal form with manganous salts, a precipitate
in excess of the latter, easily soluble in sal-ammoniac.

solutions of neutral borates of alkali-metal form with nitrate of *silver*, a
recipitate of nearly pure oxide of silver, insoluble in excess of water, easily
in ammonia or nitric acid. A concentrated solution of neutral borate forms
ver-salts, a brown precipitate which dissolves in a large quantity of water,
only a slight residue of oxide of silver. Concentrated solutions of acid
of alkali-metal form with nitrate of silver a white precipitate of borate of
ompletely soluble in a large quantity of water. Borate of ammonium forms a
ecipitate in concentrated silver-solutions, none in dilute solutions.

e borates, whether neutral or acid, give with *mercuric chloride*, a brown
te of oxychloride, insoluble in excess of the mercury-salt. Concentrated
give with neutral *mercurous nitrate*, a yellow-brown precipitate, soluble in
ater: dilute solutions, a blackish-grey precipitate which remains long sus-
Basic mercurous nitrate forms with a strong solution of borax, a dingy,
rown precipitate which dissolves in a large quantity of water, leaving black
is oxide.

solution of a calcium or magnesium salt be mixed with excess of boric acid,
he boiling solution borax be added in quantity just sufficient to neutralise the
he calcium or magnesium salt, no precipitate is formed; similarly with salts
ganous, ferrous, cobalt, nickel, cadmium and zinc salts; but solutions of
im, chromicum, ferricum, stannicum, lead and copper, yield precipitates when
ated. (Tissier.)

ne reactions of borates with fluorspar and acid sulphate of potassium before the
e (see p. 630).

TES OF ALUMINIUM.—A solution of alum mixed with alkaline borates yields
ates which, according to H. Rose, are double salts of borate of aluminium and
of the alkali-metal mixed with sulphate of potassium; water abstracts the
part of the latter and of the alkaline borate, leaving a basic borate of aluminium.
manner, the precipitate produced by monosodic borate yields sexbasic borate
inium, $2Al^2O^3.B^2O^3 + 3aq. = 6al''O.B^2O^3 + 3aq.$ [$al = \frac{2}{3}Al$], which may also
rded as an orthoborate combined with 3 at. hydrate of aluminium $= \overset{\prime\prime}{al}{}^6B^2O^6$.
^{2}.—By adding acid borate of sodium (borax) to solution of alum, a precipitate
d containing $3Al^2O^3.2B^2O^3 + 7aq. = 9al''O.2B^2O^3 + 7aq.$ or $2(al'')^3B^2O^6$.
$^3 + 4aq.$

nen, by heating a mixture of alumina and borax for a long time in a porcelain
obtained a nonobasic salt $3Al^2O^3.B^2O^3 = 9al''O.B^2O^3$ or $(al'')^3B^2O^6.6al''O$.

TES OF AMMONIUM.—Boric acid forms with ammonia, several salts which may
garded as metaborates, expressed by the general formula $M^nB^nO^{2n}$, the *n* at. M
ade up partly of ammonium, partly of hydrogen.

$H^4)^3HB^4O^8$ is obtained by saturating crystallised boric acid with dry ammonia
by dissolving one of the following salts in warm concentrated aqueous ammonia.
obtained by the former process contains 4 at., that by the latter 1 at. water
llisation.

$H^4)HB^2O^4 + \frac{2}{3}aq.$ crystallises from a solution of boric acid in excess of am-
n very efflorescent crystals of the dimetric system, soluble in 12 pts. of water.
esces like the preceding, giving off part of its ammonia.

$H^4)H^2B^4O^8 + 2aq.$ is obtained, according to Arfvedson, by dissolving boric
warm caustic ammonia, till the alkaline reaction is nearly neutralised. The
f slowly cooled, deposits rhombic crystals, exhibiting, according to Schabus,
s oP . P . ∞P. ∞P∞, and often assuming a prismatic form from the predomi-
f oP and of four P-faces situated in the same zone; sometimes twin crystals
It is permanent in the air, dissolves in 8 pts. of cold water, gives off ammonia
ng, and leaves boric anhydride when ignited. A salt called *Larderellite*, of si-
nstitution, but containing less water of crystallisation, viz. $(NH^4)HB^2O^4 + \frac{1}{2}aq.$
nd by Bechi in the boric acid formations of Tuscany, in yellowish-white,
ent, tasteless crystals, exhibiting under the microscope, the form of rectangular

tablets, and by polarised light the optical appearances of gypsum. It di
water, but the solution when evaporated deposits the salt $(NH^4)H^5B^8O^{15} + 2$

d. $(NH^4)H^4B^5O^{10} + \frac{3}{2}aq.$ (Laurent) + 2aq. (Rammelsberg). First pr
L. Gmelin, who, however, supposed it to contain 4 at. boric acid to 1 at.
(Handbook ii. 436). According to Rammelsberg, however, it has the co
above given, and is isomorphous with the corresponding potassium-salt. Ac
Laurent, it is obtained by dissolving excess of boric acid in aqueous ammon
crystallising. It forms small shining prisms of the monoclinic system, ge
cruciform groups. It is permanent in the air, dissolves in about 8 pts. of c
and, like the preceding salts, has an alkaline reaction. The solution gives of
when boiled, and the residue solidifies to a granular crystalline mass, whi
manent in the air, and appears to contain 6 at. boric acid to 1 at. ammonia.

e. $(NH^4)^2H^3B^5O^{10} + aq.$ is obtained by dissolving boric acid in aqueous
(Arfvedson.)

A solution of borate of ammonium has been successfully used for renderi
and other light fabrics non-inflammable. When tissues thus impregnated a
the flame of a candle, they are merely carbonised, the water and ammo
escape preventing the communication of the flame. If the contact with th
prolonged, the boric acid melts and forms a glassy varnish round the char
which prevents it from taking fire.

Borate of Amyl. See Boric Ethers (p. 649).

Borates of Barium.—Boric acid ignited with excess of hydrate of bari
3 at. water, and forms the *tribarytic orthoborate*, $Ba^3(BO^3)^2$. Heated with
carbonate of barium it expels 2 at. carbonic anhydride at a dull red heat,
at a bright red heat, forming the anhydrous salts, $Ba^2B^2O^5 = 2Ba''O.B^2O^3$ an
$= 5Ba''O.2B^2O^3$. (Bloxam.)

By precipitating barium-salts with borates of the alkali-metals, borates
are obtained, mostly as white crystalline powders, differing in composition
to the composition and relative proportions of the salts employed, the
ture of the solutions, and the duration of the washing. They are pr
metaborates.

a. *Monometaborate*, $Ba''(BO^2)^2 + 10aq.$ (or possibly a monobarytic or
$Ba''H^4(BO^3)^2 + 8aq.$) was obtained by Berzelius by precipitating chloride of b
monoborate of potassium. According to H. Rose, when prepared from cold
and dried at 100° C. after pressure between paper, but without washing,
composition $Ba''(BO^2)^2 + aq.$, and when precipitated from very hot solutions
more than 1aq., but less than 2aq. To drive off all the water requires a st
The salt dissolves in cold, and more readily in hot water, especially in p
ammoniacal salts, and therefore cannot be completely washed.

b. *Sesquimetaborate*. $Ba''H(BO^2)^3 + 7aq.$—Laurent obtained this salt by
solution of chloride of barium with pentaborate of sodium, under circums
particularly specified. According to H. Rose, the precipitate obtained
chloride of barium with an acid borate of alkali-metal has, when dried at 1
composition $Ba^3H^4(BO^2)^{10} + 7aq.$

c. *Dimetaborate*, $Ba''H^2(BO^2)^4 + 4aq.$, is precipitated in white flocks when
of nitrate of barium is added by drops to excess of solution of borax
ammonia. It dissolves in 100 pts. of water, more easily in ammoniacal sa
excess of chloride of barium. (Laurent.)

d. *Trimetaborate*. $Ba''H^4(BO^2)^6 + 12aq.$—Precipitated as a white
powder, when a warm solution of nitrate of barium is added by drops
stirring to excess of pentaborate of sodium.

Borates of Cadmium.—The precipitate formed on mixing the cold s
borax and sulphate of cadmium contains, after being merely pressed, the
$Cd''(BO^2)^2$, mixed with a small quantity of an acid salt. The precipitate fr
solutions consists chiefly of $2Cd''(BO^2)^2.Cd''H^2O^2 + 2aq.$

Borates of Calcium. a. *Orthoborate*. $Ca''H^4(BO^3)^2$ (dried at 100° C.).
mula might also be that of a monometaborate, $Ca''(BO^2)^2 + 2H^2O$, but the f
its constitution is the more probable, inasmuch as the salt gives off 1 at. H
only at 200° C., and is not completely dehydrated even at 300°. It is pr
precipitating chloride of calcium with monoborate of sodium, probably
solution of borax is precipitated by lime-water. It is somewhat soluble in
is decomposed by hot water.

b. *Sesquimetaborate*, $Ca''H(BO^2)^3$, appears to be precipitated, together wit
quantities of the dimetaborate, when calcium-salts are mixed with solution
(H. Rose). A similar composition appears to belong to *rhodicite*, a minera
the Ural, in small, hard, shining, yellowish-white crystals of tetrahedral
has not been exactly analysed, but appears to contain 8B to 3Ca. (G. Ros

Dimetaborate, $Ca''H^2(BO^2)^4$.—Obtained, according to Tünnermann, when borax is
itated by nitrate of calcium. It occurs also as a white efflorescence composed of
lline needles containing 5 at. water, on the plain of Iquique in Ecuador, South
ca, forming the mineral called *borecalcite*, *hydroborocalcite* or *hayesite* (Ulex).
found a calcic diborate with 3 aq. in an old lagoon-crater in Tuscany.

Tetrametaborate. $Ca''H^6(BO^2)^8$ + 3aq.—Precipitated on boiling milk of lime
xcess of boric acid.

ate of calcium occurs associated with silicate of calcium in *botryolite* and *datolite*
, and with magnesia in *hydroboracite* (*q. v.*).

RATE OF COBALT is probably contained in the glass fluxes formed with cobalt-
ounds and borax. Cold solutions of a cobalt-salt and borax yield a reddish pre-
te, which, after drying at 100° C., consists chiefly of $2Co''(BO^2)^2.Co''H^2O^2$ + 3aq.
oluble in water, and melts to a blue glass when strongly heated.

RATES OF COPPER.—It is difficult to obtain these salts in a definite state. Sul-
of copper mixed with solutions of alkaline borates yields precipitates consisting
npounds of borate and oxide of copper mixed with sulphate of soda and basic
ate of copper, which are decomposed by water, leaving a residue composed of
and borate of copper, but with less boric acid than the original precipitate.
concentrated solutions of cupric sulphate and monoborate of sodium yield a pre-
te which, after washing, consists of $Cu''H^2O^2.2Cu''(BO^2)^2$ + 2aq. The precipitate
the same solutions mixed hot is, after washing, $Cu''H^2O^2.2Cu''(BO^2)^2$. That
ed in like manner from cold concentrated solutions of cupric sulphate and borax
orthoborate containing 1 at. copper, viz. $(Cu''H)BO^3$ + $\frac{1}{2}$aq. The same pre-
te is obtained from hot concentrated solutions of cupric sulphate and borax,
ally if the copper-salt is in excess. It is a loose blue-green powder, sparingly
e in water, but decomposed by water, leaving the compound $Cu''(BO^2)^2.3Cu''H^2O^2$
. Cold *dilute* solutions of the same salts yield a precipitate containing 5Cu to
nd 10H, while the precipitate from hot dilute solutions contains 5 or 6 at. Cu to
B.

ley has suggested the use of the green precipitate obtained from cold solutions
pts. cupric sulphate (blue vitriol) and 3 pts. borax, as a substitute for the
cal greens used in painting, paper-staining, and calico-printing.

RATE OF ETHYL. See BORIC ETHERS (p. 650).

RATES OF IRON.—*Ferric monometaborate*, $Fe^2O^3.3B^2O^3$ + 3aq. or $fe''(BO^2)^2$ + 3aq.,
ot been prepared artificially, but has been found by Bechi in an old lagoon-crater
scany: hence called *Lagunite*.

ric orthoborate, $Fe^2O^3.B^2O^3$ or $fe^3(BO^3)^2$ [$fe = \frac{2}{3}Fe$], is not known in the separate
but only in combination with borate of sodium or with ferric oxide. On mixing
ution of ammonioferric sulphate (ammonia-iron-alum) with monometaborate of
m, a bulky precipitate is formed, which, after being pressed between paper, but
ashed, is a sodio-ferric borate containing $NaBO^2.2feB^2O^4$ + 3aq. Cold water
acts boric acid and borate of sodium, leaving an oxyborate, which, after drying
0° C., is $6Fe^2O^3.B^2O^3$ + 6aq. or $15fe''O.fe^2B^2O^6$ + 6aq. By precipitating
nioferric sulphate with borax, a light brown bulky precipitate is formed con-
g $NaH^5B^2O^6.2fe^2B^2O^6$ + aq., and reduced by washing with water to $24fe''O.$
O^6 + 9aq. or $9Fe^2O^3.B^2O^3$ + 9aq.

RATES OF LEAD.—*a*. The *monometaborate*, $Pb''(BO^2)^2$ + aq., is obtained, according
rapath, when the precipitate formed by borax in a neutral lead-salt is digested
me hours with strong ammonia. It is said also to be produced when a solution
sic acetate of lead is partially precipitated by borax, and, according to H. Rose,
ashing with cold water the precipitate formed on mixing the cold solutions of
and nitrate of lead. It is a white, amorphous, heavy powder, insoluble in water
n alcohol, soluble in dilute nitric and in warm acetic acid, from which solutions
precipitated by ammonia. It gives off some of its water at 120° C., the whole at
and at a red heat melts to a colourless glass, of specific gravity 5·598.

The *sesquimetaborate*, $Pb''HB^3O^6$ + $\frac{1}{2}$aq., formed by adding a large excess of borax
oiling solution of a lead-salt, resembles the preceding, gives off 1 at. water be-
170° and 200° C., and melts to a colourless glass, of specific gravity 5·235.
apath.)

Dimetaborate, $Pb''H^2(BO^2)^4$ + 3aq., obtained by boiling the salt *b* with borax.
amorphous powder, which gives off its water between 200° and 230° C., and at
heat melts to a vitreous mass (Herapath). When 100 pts. lead-oxide are
with 64 pts. boric anhydride (1 : 2 at.), a nearly colourless glass is obtained as
as flint-glass, and possessing much higher refractive power.

sic borates.—According to H. Rose, the precipitates formed with nitrate of lead
ither mono- or di-borate of sodium, are frequently basic salts, probably mixtures
onoborate and hydrate of lead, varying in composition according to the strength

of the solutions and the duration of the washing. Hot, very dilute solutions,
precipitate to which Rose assigns the formula $3(PbO.B^2O^3) + PbO.H^2O$ or $3Pb''($
$Pb''H^2O^2$ + aq.

Borochloride of Lead, $Pb''(BO^2)^2.Pb''Cl^2$ + aq., is obtained by mixing hot solu
of borax and chloride of lead, and crystallises in very small, irregular, na
needles, which are not decomposed by cold water, but gradually by boiling wate
gives off all its water between 120° and 150° C.

Boronitrate of Lead, $Pb''(BO^2)^2.Pb''(NO^3)^2$, is deposited in irregular shining cry
from a solution of borate of lead in nitric acid, evaporated till a film forms o
surface. At 120° C. the crystals give off water and a little nitric acid, and
higher temperature evolve nitrous acid and melt to a colourless glass.

Borate of Lithium.—Boric acid heated to bright redness with carbonate of lit
expels 2½ at. carbonic anhydride, forming the salt $5Li^2O.2B^2O^3$. (Bloxam.)

Borates of Magnesium. *a. Orthoborate.* $Mg^3(BO^3)^2$.—Ebelmen obtained
salt by fusing magnesia with boric anhydride, and exposing the vitreous mass
platinum dish, to the strongest heat of a porcelain furnace for several days, ti
excess of boric anhydride was volatilised. It formed radiating nacreous cryst
specific gravity 2·987. It is also obtained as a hydrate, $Mg^3(BO^3)^2$ + 10aq
boiling a mixture of borax and sulphate of magnesium, and washing the preci
(which contains borate of sodium, magnesia, and hydrate of magnesium) with
water. When boiled with water, it gives up part of its acid, and leaves a basi
which absorbs carbonic acid from the air. The precipitate formed by boiling sul
of magnesium with borax, redissolves completely on cooling.

b. *Monometaborate*, $Mg''(BO^2)^2$.—Obtained as an amorphous precipitate conta
2 at. water, on mixing the hot solutions of borax and nitrate of magnesium (Laur
The same salt, but with 4 at. water, was obtained, according to Wöhler, when a
solution of borax and sulphate of magnesium, which had been heated, and had
wards become clear by cooling, was left to itself for several months in winter
place where the temperature often fell below 0° C. It formed slender rad
needles, insoluble in water, soluble in dilute acids, reprecipitated in needl
ammonia, giving off water and becoming turbid when heated. *Boracite*, from Seg
in Holstein, appears to be a monoborate of magnesium, while that from Luneb
a mixture or compound of $3Mg''O.4B^2O^3$, or $3Mg''(BO^2)^2.B^2O^3$ with $Mg''Cl^2$.

c. *Trimetaborate*, $Mg''H^4(BO^2)^6$ + 6aq., separates, according to Rammelsbe
crystalline crusts, when a concentrated solution of boric acid is boiled with carb
or hydrate of magnesium and the filtrate is evaporated.

d. *Tetrametaborate*, $Mg''H^6(BO^2)^8$ + 2aq.—This, according to Laurent, is the
position of the last crops of crystals deposited when a solution obtained by b
boric acid with magnesium is left to evaporate spontaneously.

e. *Hexmetaborate*, $Mg''H^{10}(BO^2)^{12}$ + 13aq.—Granular salt obtained by h
hydrate of magnesium with excess of boric acid; melts to a porcelain-like
(Rammelsberg). Perhaps a mixture of one of the preceding salts wit
boric acid.

Magnesio-chromic Borate.—A salt containing $6Mg''O.3Cr^2O^3.2B^2O^3$ is obt
by heating for five days in the porcelain furnace a mixture of 20 grm. chromic
15 grm. magnesia, and 20 grm. boric anhydride, being deposited in the cavities
fused mass in grass-green microscopic crystals, of specific gravity 3·82. (Ebeln

Magnesio-ferric Borate, $6Mg''O.3Fe^2O^3.2B^2O^3$, is obtained by fusing i
manner a mixture of 25 grm. ferric oxide, 20 grm. magnesia, and 25 grm. boric
dride, in small, black, prismatic crystals, of specific gravity 3·85.

Borate of Methyl. See **Boric Ethers** (p. 650).

Borate of Nickel. Cold solutions of borax and sulphate of nickel yield a
pitate of $Ni''(BO^2)^2$ + 2aq. or $Ni''H^4(BO^3)^2$, from which cold water abstracts
acid, leaving a salt containing $2Ni''(BO^2)^2.Ni''H^2O^2$ + 4aq. By boiling for some
with borax, this precipitate is converted into the dimetaborate, $Ni''H^2(BO^2)^4$.

Borates of Potassium.—a. The *monometaborate*, KBO^2, is formed by m
together 70 pts. (1 at.) boric anhydride and 138 pts. (1 at.) carbonate of potas
It melts at a white heat, has a caustic alkaline taste, dissolves in water, and sep
slowly from the solution in ill-defined crystals which, according to Schabus, are
clinic. The solution should be evaporated out of contact with the air, as it ab
carbonic acid. Boric anhydride, heated to redness with excess of hydrate of potas
expels 2 at. carbonic anhydride, forming the salt $K^4B^2O^5 = 2K^2O.B^2O^3$. (Blox

b. The *dimetaborate*, KHB^2O^4, is prepared by supersaturating a boiling soluti
carbonate of potassium with boric acid, and then adding pure potash in suff
quantity to produce a strong alkaline reaction. It crystallises sometimes with
sometimes with 2½aq. The hydrate, KHB^2O^4 + 2aq., forms regular six-sided pr
which dissolve readily in water with strong alkaline reaction, and swell up conside

. heated. The other hydrate, $KHB\,O^4 + \frac{5}{2}aq.$: forms right rhombic prisms of 35′, with basic brachydiagonal end-faces. It behaves like the former hydrate, but kept in a closed vessel, separates into a liquid and a solid salt, apparently the ate with 2 aq.

Trimetaborate, $KHB^3O^6 + 3aq.$ or perhaps, *tri-orthoborate*, $KH^6B^3O^9$.—Obtained the preceding, but with a smaller quantity of caustic potash. Separates in rect-lar prisms, with four-sided pyramidal summits. Permanent in the air; melts out much tumefaction. (Rammelsberg.)

Pentametaborate, $KH^4B^5O^{10} + 2aq.$—Formed when a boiling solution of carbonate tassium is mixed with a sufficient quantity of boric acid to produce a strong acid ion. The solution on cooling deposits small shining prisms, isomorphous with corresponding ammonium-salt. Permanent in the air, sparingly soluble in cold, y in hot water; neutral. (Rammelsberg.)

RATES OF SILVER.—The precipitates formed in solution of nitrate of silver by ine borates vary in composition according to the dilution and temperature of the olutions. Very dilute solutions, especially if hot, yield a precipitate of pure e of silver (H. Rose). A moderately dilute silver-solution mixed with a strong ion of borax, yields a flocculent precipitate of the *monometaborate* $AgBO^2$, which dry is a white powder blackened by light. It dissolves in a large quantity of r, but is decomposed by a small quantity; melts at a gentle heat. The same is obtained as a curdy dirty yellow hydrate, $AgBO^2 + \frac{1}{2}aq.$, on mixing concen-d solutions of nitrate of silver and monoborate of sodium, or boiling concentrated ions of silver-salt and borax. It is decomposed by washing with water, especially , which ultimately leaves nothing but oxide of silver.

id borates of silver have not yet been obtained pure. Rose states that cold con-ated solutions of nitrate of silver and borax yield a white precipitate containing O to $4B^2O^3$, and after washing with a little cold water, which turns it brown, O to $5B^2O^3$. According to Laurent, nitrate of silver yields with pentaborate of sium, an acid borate of silver which decomposes partially in washing.

RATES OF SODIUM.—Boric anhydride fused with excess of hydrate of sodium s 3 at. water and forms *trisodic orthoborate*, Na^3BO^3.

$$B^2O^3 + 6NaHO = 3H^2O + 2Na^3BO^3$$

xam, Chem. Soc. Qu. J. xiv. 143). Fused with excess of carbonate of sodium at a t red heat, it expels $1\frac{1}{2}$ at. carbonic anhydride and forms $Na^6B^4O^9$ or $3Na^2O.2B^2O^3$:

$$2B^2O^3 + 3Na^2CO^3 = Na^6B^4O^9 + 3CO^2.$$

vedson, Gmelin's Handbook, iii. 87; compare Bloxam, Chem. Soc. Qu. J. xii. By fusing borax with excess of carbonate of sodium, Arfvedson found that 1 at. drous borax expelled 3 at. carbonic anhydride producing a dibasic borate of m or tetrasodic borate: $Na^4B^2O^5$ or $2Na^2O.B^2O^3$:

$$Na^2O.2B^2O^3 + 3(Na^2O.CO^2) = 3CO^2 + 2(2Na^2O.B^2O^3),$$

carbonate of sodium fused with 1 at. boric anhydride yields *anhydrous mono-borate of sodium*, $NaBO^2$ or $Na^2O.B^2O^3$, and with 2 at. boric acid anhydride, it s anhydrous acid borate of sodium, $Na^2B^4O^7 = Na^2O.2B^2O^3 = 2NaBO^2.B^2O^3$. aqueous solutions of both these salts yield crystalline hydrates which might be rded either as orthoborates or metaborates, but are most probably the latter. ecting the behaviour of the tri- and tetrasodic borates in the hydrated state, ing appears to be known.

onometaborate or *Neutral Borate of Sodium*, $NaBO^2$, is produced by heat-2 pts. of crystallised boric acid, or 191 pts. crystallised borax, with 53 pts. of anhy-s carbonate of sodium at a heat near the melting point of silver. The unfused mass obtained dissolves in water, with rise of temperature; and by cooling the hot but aturated solution, the hydrated salt $NaBO^2 + 4aq.$ (or possibly $NaH^2BO^3 + 3aq.$) allises in large oblique rhombic prisms with lateral angles of 130° and 70°. s a caustic alkaline taste, and quickly absorbs carbonic acid from the air, both in olid state and in solution; but on boiling the solutions, the carbonic acid escapes. 7° C. it melts in its water of crystallisation, and after the liquid has cooled for time the hydrate $NaBO^2 + 3aq.$ separates in indistinct crystals. At a stronger it gives off all its water, and forms a friable tumefied mass, which absorbs onic acid from the air.

imetaborate or *Acid Metaborate of Sodium*. $Na^2B^4O^7 = 2NaBO^2.B^2O^3$, or).$2B^2O^3$. *Biborate of Soda*. *Borax*.—This salt is obtained in the anhydrous state using 124 pts. crystallised boric acid with 53 pts. anhydrous carbonate of sodium, y heating crystallised borax. (A process for obtaining borax on the large scale by

heating boric anhydride with carbonate of sodium has been patented by S
Nov. 20th, 1843). In contact with water, it passes into the hydrated state
crystallises from its aqueous solution, either with 5 or with 10 at. water, according
temperature. The former hydrate is **octahedral borax**; the latter, **prismat**
ordinary borax.

Borax is found native in several localities, viz. at Halberstadt in Transylvan
Viquintizoa and Escapa in Peru, in the mineral springs of Chambly, St. Our
Canada West, but more particularly in certain salt lakes of India, Thibet, and
parts of Asia, whence the greater part of the borax of commerce was formerly obt
The salt separated from these waters by evaporation, either natural or assist
artificial contrivances, is sent to Europe as **crude borax** or **tincal**, sometin
large regular crystals, but more frequently as a white or yellowish-white mass,
is very impure, containing lime, magnesia, and alumina, and likewise covered
with a greasy substance (said to be added to diminish the risk of breakage d
transport). According to analyses by Richardson and Browell, crude Indian
contains:

Boric acid (anhydrous)	22·88	40·24	24·41
Soda ,,	12·59	11·11	11·71
Chloride of sodium	0·92	0·11	0·21
Sulphate of sodium	0·13	0·49	2·84
Sulphate of calcium	1·36	0·68	1·36
Insoluble matter	17·62	1·37	20·02
Water	44·50	46·00	39·45
	100·00	100·00	100·00

The purification or refining of this crude Asiatic borax has been carried on
very early times in various seaport towns of Europe, especially at Venice, and
lately at Amsterdam. Great pains have always been taken to keep the process
but two methods, one with *lime* and the other with *soda*, have become known :—1
tincal is macerated in a small quantity of cold water, and stirred about with g
addition of 1 per cent. of slaked lime, the turbid lime-water being poured off
time to time, and when it has clarified, again poured upon the crystals. This
ment removes the greater part of the soapy compound, and the rest is decompos
adding 2 per cent. of chloride of calcium to the solution of the crystals in hot
The insoluble lime-soap thus formed, is removed by straining, and the clear liq
evaporated to the density of 21° Beaumé.—2. The powdered tincal is placed
tub with holes in the bottom, and washed with a solution of caustic soda of s
gravity 1·034, then drained and dissolved in water, and 12 per cent. of soda
to precipitate the earths, after which the solution is strained and evaporated.
crystallisation is effected in wooden vessels lined with lead, having the form of
inverted cones.

The greater part of the borax used in the arts, is now prepared in France by
ing the native boric acid of Tuscany with carbonate of sodium, according to a m
first practised by Payen and Cartier. 1300 kilogrammes of crystallised cart
of sodium are dissolved in 1500 litres of water in a wooden vessel lined with
the liquid is heated to the boiling point by a jet of steam, and 1200 kilogra
of crystallised boric acid are added. The density of the solution varies acc
to the degree of purity and dryness of the boric acid used; it is brought to a c
strength by adding borax or water as required, then left at rest till the ins
matters have settled down, and finally transferred to the crystallising vessels.
are rectangular wooden boxes lined with lead, 6 metres long, 1·7 met. wide, and 0·
deep. The formation of prismatic or of octahedral borax, depends upon the d
of the solution, and the temperature at which the crystallisation takes place.

a. *Prismatic* or *Ordinary Borax*, $NaHB^2O^4 + \frac{9}{2}aq.$ or $2NaHB^2O^4 + 9aq.$ or Na^2O
$+ 10aq.$—To obtain this hydrate, the solution, after all the carbonic acid has e
should have a density of 21° or 22° B. (specific gravity 1·14 to 1·15), and shou
at 104° C. (220° F.) It is left to crystallise for two or three days, the crystall
being finished when the thermometer in the interior of the vessels stands at
30° C. (77° to 86° F.) The crystals thus obtained, are freed from mother-liquo
dissolved in boiling water together with $\frac{1}{20}$ of their weight of crystallised car
of sodium, to separate any remaining earths, and the strained liquid is concentr
21° or 22° B. and left to crystallise as before. The mother-liquor is then dra
as rapidly as possible with wide syphons, and that which remains amongst the
of the crystals is soaked up with sponges, so that no small crystals may depos
the larger ones. The whole is then covered and left at rest for several hours, t
the formation of cracks in the crystals, which would be occasioned by the ac
cold air.

nother-liquor is diluted with water and used in a subsequent operation for ng the boric acid and carbonate of sodium. After three or four operations, it a considerable quantity of sulphate of sodium; but on cooling it to 30° C. , borax crystallises out alone, the sulphate remaining in solution. The last liquors yield by evaporation an impure borax, which is used in glass-making.

derable quantities of borax are also prepared from the native borate of calcium ium (*Boronatro-calcite*), from South America, by decomposing it with carbonate m, either in the wet or in the dry way.

cial borax is for the most part purer than that obtained from native tincal by ning process, but the crystals often contain cracks, and split when heated, in ction of their natural cleavage, which is a great inconvenience when the borax for soldering, as it causes the crystals to fly off from the surface of the metal. lt is partially corrected by slow recrystallisation from a rather concentrated ; but it is more effectually remedied by the addition of a small quantity of before recrystallisation. (For further details of the manufacture of borax, *'s Dictionary of Arts, Manufactures, and Mines*, i. 379; *Handwörterbuch der* 2te Aufl. ii. [2] 320; *Précis de Chimie industrielle par A. Payen*, 4me ed. i. 436.)

impurities generally found in artificial borax, are carbonate of sodium, small es of sulphates, chlorides, and salts of calcium and magnesium. It is some-rposely adulterated with alum and common salt. It should dissolve in about f hot water, and exhibit no effervescence when treated with acids. The aqueous should remain perfectly clear on addition of alkali, and when acidulated tric acid, should not be clouded either by chloride of barium or nitrate of

roportion of soda in borax may be estimated by colouring the solution with and adding a standard solution of sulphuric acid, till a bright red colour is d (p. 631), and from the amount of alkali thus determined, the quantity of id may be calculated.

atic borax forms large transparent prisms, of the monoclinic system, generally tions of a nearly rectangular prism, having the acute and obtuse lateral edges d. The crystals effloresce in the air (according to Sims, only when they con-bonate of sodium). When heated, they melt in their water of crystallisation, up considerably, and solidifying to a loose spongy mass called **burnt** or **cal-borax** (*Borax usta*); at a red heat, the salt fuses to a colourless anhydrous specific gravity 2·36, called **vitrified borax**. This, if pulverised and ex- the air, gradually absorbs 10 at. water, reproducing ordinary prismatic borax.

rax with 6 at. water, $Na^2O.2B^2O^3 + 6aq.$ or $NaHB^2O^4 + \frac{5}{2}aq.$—Found by an old lagoon crater; not yet obtained artificially.

rax with 5 at. water. Octahedral Borax, $Na^2O.2B^2O^3 + 5aq.$ or $NaHB^2O^4 + 2aq.$ sibly $NaH^5B^2O^6$).—To obtain this salt, the solution (p. 646) is concentrated ngth of 30° B. (specific gravity 1·246), and left to cool very slowly in a warm The crystallisation begins at 79° C. (174° F.), and as soon as the temperature quid has fallen to 56° C. the mother-liquor must be quickly withdrawn, because temperature prismatic borax begins to crystallise out. After a few hours, the of the octahedral salt are removed and dried in the air. The crystals are transparent octahedrons, harder and less fragile than ordinary borax; they conchoïdal fracture, and specific gravity = 1·8. They are unalterable in dry in a moist atmosphere, they absorb water, and are converted into prismatic When heated, they fuse to an anhydrous glass with less intumescence than borax, and without splitting. On this account, octahedral borax is better than common borax for many purposes, as for soldering and as a flux; its proportion of water (30 per cent., that of common borax being 47 per cent.) inishes the cost of transport. Nevertheless, prismatic borax is generally pre-y consumers, probably because they are used to it, and it is sold at a lower eight for weight.

norphous Borax, $NaHB^2O^4 + aq.$—Obtained by evaporating a solution of borax C.

x is easily soluble in water, but insoluble in alcohol. Poggiale found that 100 water at various temperatures, dissolve the following quantities of prismatic

at 0° C.	2·8 pts.	at 50° C.	27·4 pts.
10	4·6	60	40·4
20	7·9	70	57·8
30	11·9	80	76·2
40	17·9	90	119·7

the boiling heat, 201·4 parts.

The aqueous solution has a slight alkaline reaction, and changes th
colour of an alcoholic solution of turmeric to brown: on adding a sma
sulphuric acid, the yellow colour is restored; but a larger addition of
sets the boric acid free, which then produces the peculiar red-brown col
mentioned (p. 639).

Borax is easily decomposed by acids. Even water, when present i
quantity, abstracts part of the base, so that a dilute solution of acid bo
reacts like a mixture of boric and the neutral borate, or even free so
example, a brown precipitate with silver-salts (p. 641). A solution o
rated with excess of hydrochloric acid leaves a mixture of chloride of so
boric acid. It also absorbs carbonic acid when exposed to the air, or
is passed into it, and on adding alcohol to the liquid, when saturated
acid, no borax separates from it. A solution of borax saturated wit
hydrogen, and mixed with alcohol, separates, on addition of ether, into
lower containing sulphide of sodium, the upper free boric acid.

Borax forms with many of the weaker acids, double salts in which
appears to act as a base to the other acid. Thus, with *arsenious acid* i
pound whose empirical formula is $3Na^2O.6B^2O^3.5As^2O^3 + 10aq$. It un
fluoride of sodium (see p. 633). When 1 at. *tartaric acid* is mixed in
2 at. borax, boric acid separates out on cooling; if the quantity of ta
gradually increased, the quantity of boric acid separated likewise inc
certain point; but beyond that it diminishes, and at last no further sepa
acid takes place. Here also the boric acid seems to play the part of ba
tartaric acid (see TARTRATES). *Acid tartrate of potassium* also forms
with borax. Of silicic acid, a solution of borax dissolves but a mere tr

Benzoic, *tannic*, and *gallic acids* dissolve in borax-solution more r
water. Many insoluble substances, *e.g. stearic* and other fatty ac
shellac, and other *resins*, dissolve in borax-solution as readily as in wea
the solution acting in fact just like a mixture of boric acid and free alk

At a red heat, on the other hand, the boric acid in borax readily u
dissolves metallic oxides, forming fusible double salts: hence the grea
in metallurgic and assaying operations, and for soldering. The co
formed often take the form of transparent glasses of various colours,
characteristic and delicate tests for the several metals: hence the u
blowpipe analysis. It is also used in the formation of easily fusible
enamels and glazes. An enamelled coating for cast-iron vessels is made
on the surface of the metal, a mixture of quartz, felspar, clay, and bo
covering it with a glaze containing borax. A glazing of 1 pt. clay, 1
2 pts. borax is also used instead of lead-glazing for stone-ware.

Borax is likewise used, though not to any great extent, in medicine,
as a remedy, external or internal, or for the formation of pharmaceutica
such as tartarised borax.

c. Tetrametaborate of Sodium. $NaH^3B^4O^8 + \frac{7}{2}aq.$—Produced
borax with 1 at. chloride of ammonium, as long as ammonia continues t

$$2NaHB^2O^4 + NH^4Cl = NaH^3B^4O^8 + NaCl + NH^3.$$

It separates from the filtrate by slow evaporation in milk-white, transp
hard crystalline crusts; dissolves in 5 to 6 pts. water of mean temperatu
alkaline solution; yields a precipitate of boric acid on addition of a *dilut*
it is distinguished from borax; melts when heated, with less tumefactio
borax. (Bolley, Ann. Ch. Pharm. lxviii, 122.)

d. Pentametaborate. $NaH^4B^5O^{10} + \frac{7}{2}aq.$—Prepared by dissolvi
and 3 at. boric acid in hot water, and separates from the solution in
aggregated in roundish masses; they do not suffer any loss of weight a
give off their water of crystallisation but slowly at higher temperatu
to which Laurent assigned the empirical formula $Na^{10}B^{48}O^{77} + 55aq.$ i
pentaborate.

e. Hexmetaborate. $NaH^5B^6O^{12}$.—Not yet obtained in the solid for
contained in the solution produced by mixing 3 at. borax dissolved in w
sulphuric acid:

$$3NaHB^2O^4 + H^2SO^4 = Na^2SO^4 + NaH^5B^6O^{12}.$$

This liquid thus formed does not redden litmus; but if 1 at. mor
acid be added, all the boric acid is set free, and the mixture exhibits
colour thereby produced, which, however, another drop of sulphuric aci
charges to bright-red (Laurent, Ann. Ch. Phys. [2] lxvii. 218). T

also formed when aqueous borax is mixed with boric acid till the liquid no hibits a basic reaction. This solution is said to yield by evaporation ystals, having a cooling taste like nitre, a neutral reaction, and giving off 30 vater when melted. (**Tünnermann.**)

e of Sodium and Calcium. $Na^2Ca''H^4(BO^2)^6$ + 18aq.—Such, with of 1·9 per cent. chloride of calcium, is, according to **Helbig** (Chem. Centr. 94), the composition of a mineral from South America, known in commerce e of lime," and forming irregular nodules, mainly composed of a net-work of t crystals. Stein regards it as identical with the hydroborocalcite of Hayes oronatrocalcite (*q. v.*) of Ulex.

s of Sodium and Magnesium. $NaMg''H^2(BO^2)^5$ + 14aq. (**Rammels-** Separates by spontaneous evaporation, from a mixture of the cold aqueous of borax and sulphate of magnesium, in large, shining, efflorescent, mono- tals. It dissolves in cold water, forming an alkaline solution which is not d by ammonia, but becomes turbid when boiled, clear again on cooling. If after boiling for some time, be quickly filtered, the residue consists of basic magnesium.

s OF STRONTIUM. 1. *Orthoborate,* $Sr^3(BO^3)^2$.—Obtained by heating ydride to redness with excess of hydrate or carbonate of strontium. , Chem. Soc. Qu. J. xii. xiv. 142.)

aborates.—The monoborate has not been obtained. Strontium-salts, pre- by borax in the cold, yield a precipitate, which when pressed between paper at 100° C., has the composition $Sr^3H^4(BO^2)^{10}$ + 5aq., gives off 2 at. water nd the rest at 300°, and is partially decomposed by hot water, the residue consisting of the sesquiborate, $Sr''HB^3O^6$.

etaborate, $Sr''H^2(BO^2)^4$ + 3aq. (at 100° C.), is said to be precipitated from lutions of borax and chloride of strontium. It has an alkaline reaction; n 130 pts. of pure water, more easily in presence of ammoniacal salts; gives I as water at 280°, the remaining atom at a red heat, leaving the anhydrous $^4O^7 = Sr''O.2B^2O^3$ ($= Sr''H^2B^4O^8 - H^2O$).

rametaborate, $Sr''H^6(BO^2)^8$ + 3aq. is obtained, according to Laurent, by e preceding with excess of boric acid, and evaporating the filtrate. Penta- potassium also precipitates strontium-salts, but the precipitate has not been

OF ZINC.—Sulphate of zinc, precipitated by borax in the cold, yields a consisting chiefly of *monoborate* of zinc, $Zn''(BO^7)^2$, which, however, is d by washing with cold water, leaving a basic salt $= 4Zn''(BO^2)^2.5Zn''H^2O^2$ t 100° C.). A solution of a zinc-salt, mixed at the boiling heat with borax for some time, yields a precipitate consisting of a similar basic borate, h basic sulphate of zinc.

Boric Ethers.

s OF AMYL. a. *Orthoborate.* $(C^5H^{11})^3BO^3$ (**Ebelmen and Bouquet,** Phys. [3] xvii. 61).—Produced by the action of chloride of boron on amylic

$$3(C^5H^{11}.H.O) + BCl^3 = 3HCl + (C^5H^{11})^3BO^3.$$

our of chloride of boron is passed into amylic alcohol, hydrochloric acid is nd the liquid quickly separates into two layers, the upper of which, when and distilled, passes over almost wholly between 260° and 280° C., and when ified, yields pure tri-amylic borate. It is a colourless, oily liquid, having a avity of 0·87 at 0° C., and a faint odour like that of amylic alcohol; it burns een-edged flame, and boils between 270° and 275° C. Vapour-density, by t, = 10·55; by calculation (2 vol.) = 9·45. Water decomposes it, yielding and amylic alcohol.

metaborate of amyl, $C^5H^{11}BO^2$, has not yet been obtained.

l borate, $2C^5H^{11}BO^2.B^2O^3$ or $(C^5H^{11})^2O.2B^2O^3$ (**Ebelmen,** Ann. Ch. Phys. 39), is obtained by pouring 2 pts. of amylic alcohol on 1 pt. of boric anhy- eating the mixture to about 180° C., exhausting it with anhydrous ether, off the ether from the decanted ethereal solution, and heating the residual 250—270° C., to free it from fusel-oil. The acid amylic borate thus ob- a clear, slightly yellowish liquid, having an odour like that of fusel-oil. It eated to 300° C. without alteration, but is decomposed at higher tempera- burns with a green flame.

usel-oil is heated to 300° C. with excess of boric anhydride, a colourless liquid r, which smells like amylic alcohol, and begins to boil below 100°; but the

boiling point rises quickly, and there remains a vitreous mass, resembling the
As acid borate of methyl gives off oxide of methyl by dry distillation, it i
that the lighter products of the distillation just mentioned contain oxide of

Borates of Ethyl. *a. Orthoborate.* $(C^2H^5)^3BO^3$. (Ebelmen and
Ann. Ch. Phys. xvii. 55; Bowman, Phil. Mag. [3] xxix. 546.)—Prepare
corresponding amyl-compound. Vapour of chloride of boron is rapidly ab
absolute alcohol, the liquid becoming hot and separating after a while into
the lower of which is merely alcohol containing hydrochloric acid, while
contains the tri-ethylic borate, which may be separated by distilling the
liquid, with addition of a little alcohol, collecting that which passes ove
115° and 125° C., and rectifying. It is likewise produced by distilling a
dry ethylsulphate of potassium and anhydrous borax. (H. Rose, Pogg. A
245.) See also vol. ii. p. 628.

It is a colourless, mobile liquid, having a peculiar, agreeable odour, a
bitter taste. Specific gravity 0·885. It dissolves in all proportions in a
ether, mixes with water, but is decomposed thereby in a few minutes, with
of boric acid. Boiling point 119° C. Vapour-density (by experiment) =
calculation (2 vol.) = 5·07. Burns with green flame, giving off white fum
acid, and leaving no residue.

Metaborate, or *Neutral Borate*, $C^2H^5BO^2$.—Produced, with separatio
acid, by the action of alcohol on the acid borate:

$$\underset{\text{Acid borate of ethyl.}}{2C^2H^5BO^2.B^2O^3} + \underset{\text{Alcohol.}}{C^2H^5.H.O} = \underset{\text{Metaborate of ethyl.}}{3C^2H^5.BO^2} + \underset{\text{Boric acid.}}{HBO^2}.$$

When the syrupy acid ether is mixed with absolute alcohol, boric acid
with considerable evolution of heat, and on separating the liquid therefrom
tation and pressure, and heating it for a while to 100° C., boric acid is again
and there remains a colourless mobile liquid, which resembles the orthob
yields by analysis 32·93 per cent. carbon and 6·97 hydrogen, the formula
33·38 C, and 6·96 H. (Handw. ii. [2] 309.)

Acid Borate. $2C^2H^5BO^2.B^2O^3 = (C^2H^5)^2O.2B^2O^3$. *Biborate of Ethyl* (
Ann. Ch. Phys. [3] xvi. 129.)—Produced by the action of boric anhydride
When finely pulverised boric anhydride is mixed with an equal quantity
alcohol at 18° C. the mixture becomes hot, quickly attaining the temperat
and begins to boil when heated to 95°. If the distillation be interrupted
the boiling-point rises to 110°, the distilled portion poured back, and the
repeated till the boiling-point again rises to 110°, acid borate of ethyl rem
retort, mixed with boric acid, from which it may be separated by digesting
for twenty-four hours with anhydrous ether, decanting from the undissolved p
distilling till the heat in the retort rises to 200°. Acid borate of ethyl th
in the form of a thick yellowish liquid, which gives off white fumes in the
and solidifies on cooling to a transparent glass. This glass is rather so
mean temperatures, and at 40° or 50° may be drawn out into long threads
faint ethereal odour, a burning taste, and blisters the skin, being at the
converted into a white powder of boric acid. It gave by analysis, 19·8 p
4·4 H, and 66·7 B^2O^3, the formula requiring 22·5 C, 4·7 H, and 65·3 B^2O^3.

Acid borate of ethyl begins to decompose at 300° C. with fusion, intumes
thickening, the products being ethylene-gas, alcohol-vapour, vapour of the
posed ether, vapour of water, and fused boric anhydride free from char
ethylene-gas burns with a green flame, the colour arising from admixed b
which, however, may be removed by washing the gas with water.

The acid ether becomes very hot by trituration with *water*, being re
alcohol, and boric acid. Exposed to moist air, it becomes white on the s
slow decomposition. It dissolves in *alcohol* and in *ether*, but gives off these l
pletely at 200° C., a portion of the undecomposed boric ether then passing ov
alcohol so that the distillate burns with a green flame, and when mixed
solidifies from separation of boric acid. The syrupy acid ether treated wi
alcohol in the manner above described, yields the neutral borate of ethyl.

Borates of Methyl.—a. *Orthoborate.* $(CH^3)^3BO^3$ (Ebelmen and Bou
Ch. Phys. [3] xvii. 59.)—Produced by the action of chloride of boron on
methylic alcohol; purified by rectifying the upper of the two resulting laye
It is a colourless mobile liquid of specific gravity 0·955; has a pungent o
what like that of wood-spirit; boils at 72° C. Vapour-density = 3·66.
in alcohol and ether, is quickly decomposed by water, and burns with a gr

b. *Acid Borate* $2CH^3BO^2.B^2O^3 = (CH^3)^2O.2B^2O^3$ (Ebelmen, Ann. Ch
xvi. 137.)—Obtained, like the acid ethylic borate, by treating boric anh

methylic alcohol. The mass is repeatedly heated to 110° C., the distillate time poured back, the residue is treated with ether, and the decanted eated to 200°. Acid borate of methyl is thus obtained as a vitreous and tenacious at ordinary temperatures. It burns in the air with a reen flame; is decomposed by distillation into boric anhydride and oxide and by water, into boric acid and methylic alcohol.

, SULPHIDE OF. B^2S^3.—This compound, which is the analogue of dride, is formed by igniting boron in vapour of sulphur (Berzelius, Pogg. 5) or in sulphuretted hydrogen; also by heating boron with sulphide of ler and Deville, Ann. Ch. Pharm. cv. 72), or by heating a mixture of boric and charcoal in vapour of sulphide of carbon (Frémy, Ann. Ch. Phys. . 819), or by strongly heating a borate in vapour of sulphide of carbon off and Rudloff, Petersb. Acad. Bull. xii. 319). To obtain a pure product, ated in sulphur vapour as long as that vapour continues to be absorbed by tion is slow, because the sulphide forms a crust round the boron.

phide of boron is a white solid body, sometimes amorphous, sometimes It has a pungent sulphurous odour, like that of chloride of cyanogen, of sulphur. Its vapour attacks the eyes. By itself it does not appear to but it volatalises in sulphuretted hydrogen, like boric acid in vapour of ated in a stream of hydrogen, it melts, and gives off a little sulphur, perhaps nly when not quite pure. It decomposes water with great energy, forming ulphydric acids, a decomposition to which, as already observed, the formation d in the Tuscan lagoons has been ascribed.

ppears also to be a persulphide of boron, produced by heating boron in pour till it takes fire, and then leaving it to cool in the vapour. When the is obtained is thrown into water, boric and sulphydric acids are formed, and phur is deposited. (Berzelius.)

ATROCALCITE. $NaCa''H^8B^6O^{18} + \frac{15}{2}$ aq.—Native borate of calcium n, called also *Hydroboracite*, *Hayesin*, and *Tiza*. (See BORATES OF SODIUM,

YOGEN. *Red vitriol.*—A native ferroso-ferric sulphate from Fahlun in ccurring rarely in small oblique rhombic prisms, having the lateral faces each other at an angle of 119° 56′, and to the terminal faces at 113° 37′; more massive and as a deposit on gypsum, sulphate of magnesium, ferrous sulphate, rites. Translucent, with vitreous lustre. Dark hyacinth-red to ochre-yellow, n gypsum. Specific gravity 2·039. Swells up before the blowpipe, giving nd leaving ferric oxide. According to Berzelius, its formula is $3Fe''O.2SO^3$ $.2SO^3) + 36H^2O$.

YOLITE. *Chaux boratée silicieuse concrétionée.* $Ca''(BO^2)^2.Ca''Si^2O^6 +$ idney-shaped mineral of delicate fibrous texture, found in the veins of ron ore at Arendal in Norway; generally as a deposit on crystals of calcspar. is the same as that of datolite, but with twice the amount of water.

ANGERITE. A tribasic sulphantimonite of lead, $3Pb''S.Sb^2S^3$ or $\acute{Sb}^2\acute{Pb}^3S^6$, Iolières in France, in Lapland, and other localities. Crystallo-laminar or d. Dark lead-grey. Sp. gr. 5·59 to 5·97.

ONITE. *Schwarzspiessglanzerz. Antimoine plombo-cuprifère:* $2Pb''S.$ $= \acute{Sb}^2\acute{Pb}^2Cu''S^6$.—Crystallises in right rectangular prisms of dark steel-grey h metallic lustre, and yielding a black powder. Hardness equal to that of Specific gravity 5·7 to 5·8. Melts before the blowpipe, giving off white ering the charcoal with oxide of lead, and changing to a slag containing a tity of copper. It is found in the copper mines of Cornwall, at Neudorf asberg in the Harz, at Kapnik and Offenbanya in Transylvania, &c., but is oundant. Some varieties found near Freiberg contain silver to the amount 12 per cent. (Gm. v. 486.)

COAL. A kind of coal of a brown or brownish-black colour and lamellar e laminæ being often flexible when first dug out, but generally hardening by o the air. It consists of wood penetrated with petroleum or bitumen, and contains pyrites, alum, and protosulphate of iron. By distillation, it yields or mixed with ammonia and an oil partly soluble in alcohol. It is found , France, Italy, Switzerland, Germany, Iceland, &c.

NITE. See SERPENTINE.

'S FUMING LIQUOR. *Monosulphide of Ammonium* (p. 193.)

ITE. A mineral found at Arendal in Norway, but not yet sufficiently ex- establish its separate identity. (Forbes and Dahll, J. pr. Chem. lxvi. 446.)

BRAIN. See Nervous Tissue.

BRAN. *Son. Kleie.* (Millon, Ann. Ch. Phys. [3] **xxvi.** *5.* Pél
5. Kékulé, Liebig's chem. Briefe, 3 Aufl. i. *595.* Wetzel and Va
Pharm. [2] lxvii. 284. Poggiale, Compt. rend. **xxxvii.** **171**; **xli**
Dingl. pol. J. cxxxi. 298. Mouriès, Compt. rend. **xxxvii.** **351**; **x**
431. Oudemans, Rep. chim. app. i. *585.*)—The husky portion
separated by the boulter from the flour. The analyses which have b
even from the same kind of corn, differ widely in the proportion of sc
tial constituents, as the following table will show.

	Rye-bran.	*Wheat-bran.*			
	Oudemans.	Oudemans.			Poggiale.
Ash	3·35	6·52	6·26	4·99	5·5
Water	14·55	14·07	14·27	14·40	12·7
Fat	1·86	2·46	2·88	3·88	2·9
Nitrogenous matter (gluten, &c.) .	14·50	13·46	12·68	15·41	13·0
Dextrin	7·79	5·52	5·24	5·71	7·9
Starch	38·19	26·11	29·74	29·31	21·7
Sugar					1·9
Cellulose	31·35	30·80	27·11	25·98	34·6
Resinous and odoriferous matter .					
	101·59	98·94	98·28	99·68	100·0
Nitrogen	2·23	2·07	1·95	2·37	·

Kékulé's determination of the nitrogenous matter is probably too
per cent. nitrogenous matter found by Poggiale was made up of 5·
(albumin), 3·9 insoluble, but capable of assimilation, and 3·5 insolu
of assimilation. Poggiale isolated the cellulose by rendering the sta
diastase; he finds that the usual process of determination by the succes
and alkalis, always gives the amount of cellulose too low, part of it
by those reagents into sugar and dextrin.

Bran, though rich in nitrogen, appears to possess but little nutritive
fed upon it quickly lose flesh (Poggiale). It contains a nitrogenous
cerealin, analogous to diastase, and perhaps identical therewith, wh
power of quickly converting starch into dextrin and sugar. Mouriès fo
of wheaten bread containing bran easily diffused through 520 parts of
turated therewith, and yielded 59·35 pts. of soluble and 69·75 pts. of i
whereas the same quantity of bread not containing bran, was convert
with water into a semisolid mass, and yielded only 9·03 per cent. s
120·25 insoluble. This action of the bran on the flour commences i
and baking, but is completed only in the stomach. (See Bread.)

Bran is used by calico-printers in the clearing process, for removin
matters adhering to the non-mordanted parts of the maddered goods, a
matters which cloud the mordanted portions. (See *Ure's Dictionary*
factures, and Mines, i. 383.)

BRANCHITE. C^9H^{16}.—A fossil hydrocarbon from the lignite o
Tuscany. It is colourless and translucent, like Scheererite; melts at
not crystallise on cooling. It dissolves in alcohol. Specific gravity
Leonhard and Bronn's Jahrbuch, 1842, p. 459.)

BRANDISITE. See Clintonite.

BRANDY. This well known liquor is the spirit distilled from
an extensive article of trade in the south of Europe. It is generall
from white or pale-red wines, but often from inferior articles, such as
and the marcs of the wine-press. Distillation of the wines is the onl
sary for procuring brandy: hence the richer the wine in alcohol, the
the yield of brandy. Many circumstances, however, independent of the
fluence the quality of the product. Thus, white wines do not always aff
than the red, but they yield a spirit of finer quality, because they con
essential oil of grapes. Wines which have a certain taste of the soil.
to the brandy derived from them by distillation; thus, the wines of Sell
give a brandy which has the odour and taste of the Florentine iris; th
in Vivarais, give a spirit which smells of the violet, and so of many

Real Cognac is obtained from the distillation of choice wines, every
paid to the proper degree of cleanliness in the various utensils employ
proved form of still, a very superior article is obtained from inferior
small proportion of essential oils in such wines divests the brandy o

belongs to the better sorts of wine, and is communicated to the brandies them. An inferior brandy called *eau-de-vie de marcs* is obtained by dis- k red wines of Portugal, Spain, and other wine-growing countries, also ted by wine in keeping, the marc or refuse of the grapes from the wine- bings of wine-casks, &c.

old in France. is generally of two strengths, designated as *à preuve de* *à preuve d'huile*, the former varying from 18° to 20° Beaumé. The s are valued according to the quantity of *eau de vie à preuve de Hollande* antity will furnish on the addition of the proper quantity of water. s are usually twelve, viz. of *five-six*, *four-five*, *three-four*, *two-three*, *seven*, *five-nine*, *six-eleven*, *three-six*, *three-seven*, *three-eight*, and *three-* st is rarely made. The meaning of these strengths is as follows: — If *six*, 5 pts. of the spirit will give a liquor *à preuve de Hollande*, when easures of water. The spirit five-six has a specific gravity of 0·9237 or all the other strengths are variable, on account of the uncertainty of the spirit *à preuve de Holland*.

g is an average of the yield of brandy which some wines afford by dis-

of wine of St. Gilles, in the environs of Montpellier, afford

of three-six brandy	150 litres
of good wine of calcareous soils	140 „
of wines of fertile soils near Montpellier . . .	100 „
of wines of soils producing much grapes . . .	100 „

countries nearest the Mediterranean furnish the largest proportion of diminishes as the grapes grow in more northern countries.

dy is an artificial product fabricated by the rectifying distiller. The ot is given by Ure: — "Dilute the pure alcohol to the proof pitch, and ndred pounds weight of it from half a pound to a pound of argol—crude ed in water, some bruised French plums, and a quart of good cognac. ture over a gentle fire in an alembic provided with an agitator. The ndy and argol introduces œnanthic ether, and if a little acetic ether be stillate, the whole imparts the peculiar taste of genuine Cognac brandy. rnt sugar if necessary, and add a little tannic acid to impart astrin- *Ure's Dictionary of Arts, Manufactures, and Mines*, i. 389; also *Mus- ry*, i. 103.)

An alloy of copper and zinc. (See Copper; also *Ure's Dictionary of tures, and Mines*, i. 399.)

A. A genus of cruciferous plants, including some of the most impor- nts and culinary vegetables, viz. the cabbage, rape, and turnip.

oleracea. Cabbage.—Of this species, many varieties are cultivated for y. the common red or white cabbage (*Br. ol. capitata*), the Savoy cabbage), curled kale (*Br. ol. acephala*), &c. The turnip-stemmed cabbage, or *ol. caulorapa* or *napobrassica*), is much cultivated in France and s fleshy turnip-like stem or bulb, which makes an excellent vegetable wer and broccoli are also varieties of *Brassica oleracea*.

cabbage-leaves contain 0·2 per cent. nitrogen; the dried leaves 3·7 per ngault, Ann. Ch. Phys. [2] lxviii. 337). Table A exhibits the compo- ge leaves as determined by Anderson (Chem. Centr. 1856, p. 232).— ng plant before the heart-leaves are formed. *b.* The outer leaves of abbage. *c.* The heart-leaves of the same.

Table A.—*Composition of Cabbage-leaves.*

	a	*b*	*c*
buminous substances . . .	2·1	1·6	3·9
oody fibre, gum, and sugar . .	4·5	5·0	4·1
h	1·6	2·2	0·6
ter	91·8	91·1	94·4

Sprengel (J. techn. Chem. xiii. 485), white cabbage contains, in the 52·5 per cent. water, 19·3 per cent. matter soluble in potash-ley, 25·6 per re, besides wax, chlorophyll, &c. The ash of cabbage has been analysed gston (Journ. Roy. Agr. Soc. vii. [2] 593; xi. [2] 512), by Sprengel ner (Ann. Ch. Pharm. lxx. 294).

tem or bulb of the kohl-rabi contains, according to Sprengel (*loc. cit.*) ter, the leaves 86 per cent. water. 100 pts. of the dried substance con- soluble in water, 38·2 soluble in potash-ley, 18·5 woody fibre, besides wax, fat, &c. The ash of the corms and leaves has been analysed by by Way and Ogston (*loc. cit.*)

The ashes of the heart of cauliflower (*Br. ol.* var. *botrytis cauliflora*), and leaves of broccoli (*Br. ol.* var. *botrytis asparagoides*) have bee Th. Richardson, Ann. Ch. Pharm. lvii.; Anhang zum dritten Heft).

TABLE B.—*Ash of different Varieties of Brassica olerac*

	Way and Ogston.		Sprengel.	Stammer.	Way and Ogston.		Spreng
	Cow Cabbage		*White Cabbage*		*Kohl-rabi*		
	Leaves.	Stalk.			Bulbs.	Leaves.	Bulbs.
Ash in 100 pts. of fresh plant	0·7	1·2	—	—	—	—	0·95
" " " air-dried plant	—	—					—
" " " plants dried at 100° C.	10·0	—	7·55	11·62	7·05	12·90	8·09
Composition of ash in 100 pts.:							
Potash (anhydrous)	40·9	40·9	31·3	48·3	37·6	17·8	36·3
Soda "	2·4	4·0	12·0	—	13·3	8·1	2·8
Lime	15·0	10·6	23·1	12·6	11·1	34·2	10·2
Magnesia	2·4	3·8	0·3	3·7	4·0	3·2	2·3
Alumina	—	—	0·2	—	0·5	0·2	—
Ferric oxide	9·8	0·4	0·1	1·8	0·5	0·9	0·4
Sulphuric anhydride	7·3	11·1	12·7	8·3	12·6	14·0	11·4
Silicic "	10·6	1·0	2·8	0·4	6·7	7·1	0·8
Carbonic "	16·7	6·3	—	—	—	—	10·2
Phosphoric "	12·5	19·6	10·4	16·9	5·8	5·4	13·5
Calcic, magnesic, and ferric phosphates	—	—	—	—	—	—	—
Chloride of potassium	—	—	—	9·3	—	—	—
" " sodium	trace	2·1	6·0	—	6·1	7·8	11·9

2. *Brassica Napus.*—Winter rape, Coleseed, and *Br. campest* Summer rape, Colzat or Colza, are cultivated chiefly for their se a large quantity of oil, and for the succulent food which their thick f leaves supply to sheep when other fodder is scarce. The cake which r oil has been pressed from the seed, is used on the continent as food fo and also as a manure, for which purpose large quantities of it are imp land. Colza or summer rape yields the largest quantity of oil, but wi to be hardier, and is therefore more generally cultivated in this country. Roy. Agr. Soc. x. part 2) found, in 100 pts. of the dry seed of dwarf ra nitrogen, 37·8 fat, 3·3 ash, and 6·5 water. Of the ash of the seed an numerous analyses are given in Liebig and Kopp's *Jahresbericht für C* tables D and E to page 656. From these we extract the following:

TABLE C.—*Ash of the Seed and Straw of Brassica Napu*

	Liebig.	Erdmann,	Rammelsberg
	Seed.	Seed.	Seed.
Ash in 100 pts. of air-dried plant	—	—	—
" " " plant dried at 100° C.	5·19	4·03	4·44
Composition of ash in 100 pts.:			
Potash	22·5	22·7	25·7
Soda	0·2	—	—
Lime	11·8	14·6	13·2
Magnesia	11·1	12·0	11·6
Ferric oxide	1·7	0·6	0·6
Sulphuric anhydride	6·7	0·5	0·5
Silicic "	6·0	1·1	1·1
Carbonic "	—	—	—
Phosphoric "	39·1	47·0	47·0
Chloride of potassium	—	—	—
" sodium	0·8	—	—

3. *Brassica Rapa*, the common white turnip, and *Br. campestri* or *napobrassica*, the swede turnip.—The ashes of these plants have by T. J. Herapath (Chem. Soc. Qu. J. ii. 14), Eggers (Jahresber. p. 656); Baer (*ibid.* 1851, p. 710); Stammer (Ann. Ch. Pharm. lxx. 2 and Ogston (*loc. cit.*).

TABLE D. — *Composition of Turnip-ash.*

	Herapath.		Way and Ogston.							Baer.		Stammer.	Eggers.
	Swede	*White*	*Swede*		*Dale's Hybrid*		*Green topped white*						
	Bulbs	Bulbs.	Bulbs.	Leaves.	Bulbs.	Leaves.	Bulbs.	Leaves.	Seed.	Seed.	Straw.	Bulbs.	Oil-cake.
of fresh . . .	1·23	0·65	0 75	1 97	1·09	1·19	0 59	1·82	3·67			0·46	5·70
of air- . . .	—	—	—	—	—	—	—	—	—	4·58	4·41		
of plant C. . .	—	—	6·00	16·40	8·41	10·80	7·40	15·20	3·98	—	—	7·00	6·13
the ash													
. . .	62·6	47·9	23·7	11·16	36·9	13·5	48·5	12·7	21·9	16·1	16·5	46·5	21·9
. . .	trace	—	14·7	12·4	8·0	4 6	—	—	1 2	1·1	1·3	—	—
. . .	6·9	14·7	11·8	24·5	6·5	35·1	6·7	28·7	17·4	11·3	25·4	13·1	8·6
. . .	2·5	2·4	3·3	2·6	2·5	1·7	2·3	2·8	8·7	10·4	11·0	1·6	14·7
. . .	trace	—	—	—	—	—	—	—	—	0 5	0 2		
. . .	0·25	trace	0·5	3 0	0·1	0·6	0 6	0·8	1·9	1·0	1·2		4 5
ydride .	4 2	2 6	16·1	10·4	11·7	6 7	12·8	7·8	7·1	7·9	5·5	9·9	1·6
„ .	0·1	1 2	2·7	8·0	2·7	1 2	0·9	2·0	0·7	9·9	3·4	1 0	13·1‡
„ .	—*	—	10·7	6 2	12·6	13·8	14·8	14·6	0·8	6·9	27·6		2·1
„ .	15·9	16·6	9·3	4·9	8·8	4·6	7·6	3·1	40·1	34·0	4·0	15·5†	32·7
tassium	7·4	—	—	—	—	—	—	15·5	—	—	—	10·6	0 2
dium .		14·6	7·1	12·4	10·0	18·0	5·4	10 7	—	0·8	3·2	—	0·5

SSIC ACID. Colza oil is, according to Websky (J. pr. Chem. lviii. 449), e of two glycerides, which yield by saponification, brassic acid, which is ordinary temperatures, melts between 32 and 33° C., and crystallises from long needles; and another acid, which is liquid at ordinary temperatures nbles oleic acid. The two acids are easily separable by means of their lead- salt of the oily acid being soluble in ether, while brassate of lead is insoluble. assigns to brassic acid the formula $C^{45}H^{42}O^4$. Städeler (Ann. Ch. Pharm. 33) proposes $C^{44}H^{42}O^4$, or $C^{22}H^{42}O^2$, which agrees quite as well with the and is the same as that of erucic acid, extracted by Darby from oil of Brassate of sodium gives by analysis 8·5 per cent. soda; the formula O^2 requires 8·6 per cent.

UNITE. Native sesquioxide of manganese. See MANGANESE.

UNSTEIN. The German name of peroxide of manganese.

YERA ANTHELMINTICA (Kunth), or *Hagenia abyssinica* (Lamarck). owers of this plant, called *Kusso* or *Kosso*, contain, according to Viale and (Correspond. Scient. in Roma, Nov. 1852), a peculiar acid, *hagenic acid*, in ion with ammonia.

s (Arch. Pharm. [2] lxxxviii. 165) found in 100 pts. of the ash of kusso, ucting sand and charcoal:

CO^2	SO^3	P^2O^5	SiO^2	$Fe^2O^3.P^2O^5$	NaCl
3·58	1·90	14 43	3·14	5·50	7·38
l^2O^3	Mg^2O	Ca^2O	Na^2O	K^2O	Mn^2O^3
.97	6·43	13·37	13·41	18·89	trace

ZIL WOOD. The tree which yields this wood, the *Cæsalpina crispa*, grows , and also in the Isle of France, Japan, and elsewhere. There are several distinguished by the names of the localities from which they are obtained, as uco, Lima, Santa Martha, Sapan (from Japan), &c. Pernambuco wood a wood contain the largest amount of colouring matter; viz. about 2·7 per apan wood, only about 1·5 per cent. Peach or Nicaragua wood, sometimes anta Martha wood, is still inferior in point of quantity, but is preferred for poses.

wood is heavier than water, very hard, and susceptible of a good polish. ur is pale when newly cut, but becomes deeper by exposure to the air. The specimens generally yield the best colour. It has a sweetish taste when and is distinguished from red sanders or sandal wood by giving out its colour which sandal wood does not. The colouring matter may also be extracted ol or ammonia, and with greater facility than by water. The spirituous according to Dufay, stains warm marble of a purplish red, which, on in- the heat, becomes violet; and, if the stained marble be covered with wax and considerably heated, it changes through all the shades of brown, and at last fixed of a chocolate colour.

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* In the calculation of Herapath's analysis, the carbonic acid is deducted.

† Mixed with sand.

‡ And 1·5 basic ferric phosphate.

According to **Chevreul** (Ann. Chim. lxvi. 226), the red colouring matter wood, to which he gives the name *Brazilin*, exists ready formed in the woo simply dissolved out by water or other solvents. To prepare it, the wo hausted with warm water; the solution evaporated to expel free *acetic acid*; residue is dissolved in water; the liquid shaken up with oxide of lead, to re remaining free acids; the filtrate again evaporated to dryness; the residue in alcohol; the alcoholic solution likewise evaporated; the residue dis water, and the solution treated with gelatin to precipitate tannic acid: evaporation and solution in alcohol must be repeated to remove the excess o (**Chevreul.**)

Brazilin crystallises by spontaneous evaporation in reddish yellow needl soluble in water, alcohol, and ether. The solutions have a fine red colour, i not contain free acid; but the addition of sulphuric, nitric, or hydroch changes the colour to dirty yellow; hydrofluoric acid turns it first ye greenish grey; phosphoric and citric acids give it a fine and permanent yell whereas with acetic acid a yellowish-red solution is formed, which when eva contact with the air, leaves a residue of a fine red colour. The yellow pr citric acid is well adapted for dyeing wood or silk.

By sulphydric, sulphurous, hyposulphuric, and boric acids, the colouring bleached and destroyed; a similar action is exerted upon brazilin by zinc a acids.

Alkalis change the red colour of a solution of brazilin to violet or blue: fusion of Brazil wood may be used as a test for these bases; with h alumina it forms a crimson lake; with tin- and lead-salts, purple pr (**Chevreul.**)

According to **Bolley** (Zeitschr. Ch. Pharm. viii. 192), brazilin is ide sapan-red, the colouring matter of Sapan-wood (*Cæsalpinia echinata* or *C. S* is obtained therefrom with much greater facility than from Brazil wood. (RED, vol. v. p. 191.)

The precipitates obtained with an aqueous decoction of Brazil wood, sively used for dyeing and for staining paper for walls. The solubility of th matter of Brazil wood, and its strong affinity for mordants, give it a ver range of application both in dyeing and in calico-printing. (For details res mode of dyeing with Brazil wood, see *Muspratt's Chemistry*, vol. i. p. 573. *Dictionary of Arts, Manufactures, and Mines*, vol. i. p. 397.)

BREAD. Bread consists of the flour of wheat or other cereal grai with water into a paste or dough, which is rendered porous by the interpen carbonic acid gas, either generated within the mass of the dough by ferme forced into it by mechanical means. The dough having thus acquired degree of porosity, is exposed to the heat of an oven, whereby the enclo further expanded, its escape being prevented by the simultaneous formati crust. The crumb of the bread thus produced is a soft porous mass of sw otherwise unaltered starch, mixed with vegetable fibrin; in the crust, th mainly converted into dextrin and empyreumatic products.

It is the rising of the dough, produced by the carbonic acid, which gi made bread its peculiar lightness, and distinguishes it from the close, heavy duced by merely mixing flour with water and baking it. The usual metho rating the carbonic acid is by fermentation, and the manner in which this conducted has great influence on the quality of the bread; as, if it be not enough, the dough will not rise sufficiently, and if allowed to go too far, it to the formation of acid and other objectionable products. To facilitate standing of it, we must give some account of the composition of flour.

The flour of all cereal grains consists of an azotised portion, chiefly vegeta a non-azotised portion, chiefly starch, with variable quantities of dextrin and inorganic salts, chiefly phosphates.

If moistened wheat flour be kneaded into a stiff paste, and well washed a milky liquid runs off, and a viscid elastic solid, called **gluten**, is left beh milky liquid, if left to stand, deposits a quantity of **starch** mixed with m ticles of gluten, and the clear liquid filtered from the deposit, leaves on eva quantity of **extractive matter**, consisting of vegetable albumin, dextri or grape-sugar, possibly also gum, and other similar proximate principle soluble inorganic salts. The gluten, which is essentially the flesh-forming c of the flour, consists of vegetable fibrin, held together by a very tenacious n substance, called *glutin* or *gliadin*, which may be extracted by alcohol; i

quantities of fat, and fine particles of bran mechanically mixed. It is the
ich gives to the nitrogenous portion of wheat-flour its peculiar adhesiveness,
the dough prepared with it to rise into a spongy mass when penetrated by
her cereal grains, oats and rye for example, though rich in vegetable fibrin,
rcely any gliadin, and consequently the dough prepared from them possesses
enacity. This is the chief cause of the great superiority of wheat over all
ls, for the preparation of bread.

our in the moist state is exposed to the air, the nitrogenous matter quickly
a peculiar state of decomposition, in which it is capable of acting as a fer-
erting the starch into dextrin and glucose, and the glucose into alcohol and
id (see **Fermentation**). Hence a portion of dough which has been left till
es partial decomposition, and in which state it is called **leaven**, is capable
the so-called *panary*, but really *alcoholic* fermentation, in a much larger
f dough, when well kneaded with it. "A little leaven leaveneth the whole
his method of bread-making has been practised from the oldest times, and
only one in use for the coarser kinds of bread, such as the *Schwarzbrot*, or
d of Germany; but for the finer sorts, beer-yeast is now used as a substitute,
as a partial substitute of leaven. The process generally adopted in this
as follows: A certain quantity of flour is mixed with yeast, salt, and tepid
his constitutes the "sponge," which is covered up and set aside in a warm
ndergo fermentation. In the course of an hour or so, the mass swells up
ly from the generation of carbonic acid, large bubbles of which rise to the
d burst. With each successive burst, a sudden falling of the sponge takes
wed by a gradual rising, and these alternate actions would, if allowed, con-
nany hours. Various other modes of making an active sponge are employed,
y by the use of potatoes. When the sponge, no matter how formed, is in an
ndition, the baker mixes up with it fresh portions of flour, salt, and water, the
so added forming the greater part of the dough. The whole is then subjected
gh kneading with the hands, or sometimes with the feet, so that the ferment-
may permeate and affect the entire substance, and thus cause an equable
of carbonic acid in every particle. The dough is set aside for a few hours,
ich the fermentation proceeds, then kneaded a second time, and weighed out
s, which are allowed to continue fermenting till they have doubled their
lk. They are then baked in the oven, within which they undergo a further
f size, due chiefly to the expansion by heat of the confined gases: for the
e oven quickly arrests the fermentation.

, where bread-making has been brought to a high degree of perfection, the
on is produced chiefly by the gluten of the dough, yeast being used merely
e the action. A lump of dough remaining from the last batch of bread, and
of 8 lbs. flour and 4 lbs. water, is left to itself for ten hours: in this state
fresh leaven (*levain de chef*). By kneading this with another quantity
lour and 4 lbs. water, the **once-revived leaven** (*levain de première*) is
After another interval of eight hours, 16 lbs. of flour and 8 lbs. water are
ming the **twice-revived leaven** (*levain de seconde*); and after three hours
lbs. flour and 52 lbs. water containing ¼ to ½ lb. beer-yeast are added, form-
nished leaven (*levain de tout point*). The 200 lbs. leaven thus obtained
, after two hours, with 132 lbs. flour and 68 lbs. water, containing ½ lb. of
uspension and 2 lbs. common salt dissolved. This quantity of dough serves
r six bakings. For the first baking, half the dough (200 lbs.) is made
s of the required size and form, which are exposed for a while in shallow
a temperature of 25° C. (77° F.), and then transferred to the oven. The
obtained has a sourish taste and dark colour. The remaining half of the
gain mixed with 132 lbs. flour, 70 lbs. water, ½ lb. yeast, and the requisite
f salt; the half of this quantity of dough is then formed into loaves, left to
nd baked. The same operations are repeated three times, one-half of the
ng each time mixed with 130 lbs. flour, 1½ lb. yeast, and the proper quantity
nd salt. The last stage yields the finest and whitest bread.

normal process of bread-making, the carbonic acid, whose evolution gives
o the bread, is derived principally, if not wholly, from the fermentation of
of the flour, induced by the action of metamorphic gluten. But flour, as
served, contains other nitrogenised substances than gluten, and other non-
ed substances than sugar. Now these nitrogenous substances, the albumin,
le, readily undergo transformation, and then act as ferments, not only upon
dextrin, but also upon starch, transforming it into dextrin and sugar, and
also into lactic acid. This is the process which takes place in the germination
n malting for example (p. 328), by the action of the albumin in the peculiar
d *diastase*. Now when wheat has been too much exposed to damp during

harvesting, or has sprouted from any subsequent cause, or when the flour even of well-harvested wheat is exposed to heat and moisture, the albumin passes into this peculiar state, and the flour becomes incapable of yielding good bread, because, during the process of bread-making, the conversion of starch into dextrin and sugar, which always occurs to a slight extent, then takes place in an exaggerated degree. Bread made from such flour, is sticky, saccharine, and soddened, never light and porous. The conversion of the starch into dextrin and sugar likewise renders the bread darker in colour. In fact, the brown colour of wheaten bread made from flour containing fine bran, is due, not to admixture of particles of bran, but in great part at least to a conversion of the starch into dextrin and sugar by the action of the altered albuminous matter in the bran. According to Mège-Mouriès, bran contains a peculiar nitrogenous body called *cerealin*, which is specially active in inducing this conversion: it appears, however, to be identical or nearly identical, with ordinary diastase. Be this as it may, it is certain that the finest wheat flour obtained from the central portion of the grain, which contains but little nitrogenous matter, has very little tendency to undergo the change under consideration; but coarse flour obtained from the exterior of the grain, is rich in azotised substances, and more ready to undergo the glucosic deterioration. In white bread of good quality, the starch has undergone very little alteration. A small portion of it is rendered soluble in water, but the greater number of the granules are simply swollen, not burst, and may be washed out of the bread, collected and weighed. Vogel gives the following analysis of a wheat-bread loaf: sugar, 3·6 per cent.; altered starch, 18·0; unaltered starch, 53·5; gluten, with some starch, 20·7 = 95·8.

The injurious action of diastase, &c. on starch in the process of bread-making may be prevented by the addition of certain mineral substances. **Alum** has long been employed for this purpose by bakers, and it certainly has the effect of rendering available for bread-making many qualities of flour, which must otherwise be wasted. Dr. **Odling** says (Journal of the Society of Arts, April 9, 1858): "If we mix a solution of starch with infusion of malt, in the course of a few minutes only, the starch can no longer be detected, being completely converted into dextrin and sugar, but the addition of a very small quantity of alum prevents altogether or greatly retards the transformation. The action of diastase on undissolved starch is very gradual, but here also the interference of the alum is easily recognisable. Bread made with infusion of bran or infusion of malt, is very sweet, sodden, brown-coloured, and so sticky as almost to bind the jaws together during mastication. But the addition of alum to the dough causes the loaves to be white, dry, elastic, crumbly, and unobjectionable, both as to taste and appearance. I have found that flour which is of itself so glucogenic as to yield bread undistinguishable from that made with infusion of malt, could, by the addition of alum, be made to furnish a white, dry, eatable loaf."

Alum is also said to prevent bread from turning sour and mouldy. The sourness often observed in bread of inferior quality, arises from the conversion of part of the starch into lactic acid. Now as alum prevents the transformation of starch, it may be expected also to interfere with the production of lactic acid.

Considerable discussion has taken place as to the probable effects of the habitual use of alumed bread on the digestive functions, some medical men asserting that alum, unless taken in much larger quantity than is likely to occur in bread, is quite harmless, while others attribute to it the most injurious effects. In this, as in many cases, the truth probably lies in the middle. Many of the statements which have been put forth on this, as on other questions relating to the adulteration of food, are doubtless grossly exaggerated; nevertheless, it would be unsafe to assert that the use of alum is quite free from objection. Dr. Dauglish, in a paper to which we shall have again to refer, says: "Its effect on the system is that of a topical astringent on the surface of the alimentary canal, producing constipation, and deranging the process of absorption. But its action in neutralising the efficacy of the digestive solvents, is by far the most important and unquestionable. The very purpose for which it is used by the baker, is the prevention of those early stages of solution which spoil the colour and lightness of the bread whilst it is being prepared, and which it does most effectually: but it does more than needed: for whilst it prevents solution at a time that is not desirable, it also continues its effects when taken into the stomach, and the consequence is, that a large portion of the gluten and other valuable constituents of the flour, are never properly dissolved, but pass through the alimentary canal without affording any nourishment whatever."

Another objection made against the use of alum, viz. that it has the power of causing bread to retain a larger proportion of water than it otherwise would, so that bakers who use alum defraud their customers by selling water instead of bread, does not appear to rest on satisfactory evidence. **Odling** (*loc. cit.*) examined the new crumb of eighteen alumed and seven non-alumed loaves, and found that the former contained

43·68 per cent., and the latter, 42·78 per cent. water, the difference being
cant as compared with the differences between the individual loaves,
ed or not. The detailed results, together with the proportions of
ash in the loaves, are given in the following table, the samples marked
sk being the *non*-alumed loaves. They are interesting in a general point
endently of the alum question. The loaves were new, that is, obtained
y on which they were baked.

of Water, Nitrogen *and* Ash, *in Bread Alumed and Non-alumed.*

n .	Percentage of Water.	Percentage of Organic Matter.	Percentage of Mineral Matter or Ash.	Percentage of Ash in dry Bread.	Percentage of Nitrogen in new Bread.	Percentage of Nitrogen in dry Bread
	43·03	55·48	1·49	2·61	1·83	3·21
	42·86	56·07	1·07	1·87	1·47	2·57
	44·81	53·74	1·45	2·62	1·89	3·42
	46·71	52·12	1·17	2·19	1·14	2·13
	45·42	53·24	1·34	2·45	1·66	3·05
	44·33	54·29	1·38	2·47	1·04	1·88
	44·41	54·38	1·21	2·17	1·06	1·90
	38·62	59·79	1·59	2·58	1·15	1·47
	42·77	56·00	1·23	2·15	1·31	2·29
	43·67	55·09	1·24	2·20	0·93	1·66
	42·94	55·82	1·24	2·17	1·12	1·95
	44·20	54·61	1·19	2·13	1·14	2·05
	45·12	53·55	1·33	2·43	1·17	2·15
	44·34	54·41	1·25	2·28	1·23	2·21
	43·70	55·07	1·23	2·18	1·01	1·81
	43·06	55·59	1·35	2·39	1·24	2·18
	43·90	54·92	1·18	2·11	1·13	2·03
	42·12	56·65	1·23	2·12	1·23	2·14
	42·58	55·99	1·43	2·50	1·34	2·34
	41·06	57·23	1·71	2·90	1·39	2·38
	44·07	54·67	1·26	2·26	1·08	1·94
	44·46	54·22	1·32	2·38	1·18	2·14
	43·43	55·24	1·33	2·35	1·19	2·10
	42·89	55·68	1·43	2·52	1·17	2·05
	41·34	57·76	0·90	1·54	1·33	2·27
	1085·84	1381·61	32·55	57·57	31·53	55·72
	43·43	55·26	1·30	2·30	1·26	2·22

ter has also been recommended to prevent the transformation of starch
cation into dextrin, sugar, and lactic acid. It was first suggested by
s said to have been used to a considerable extent by the Glasgow bakers.
from laboratory experiments, that lime-water is quite as effective
eventing the action of diastase upon starch, but seems to have scarcely
on the fermentation induced by yeast, or, at any rate, a much less action
hich certainly retards the process in a perceptible degree. In this respect
ter possesses an advantage over alum; it would also doubtless be con-
bjectionable in its direct action on the digestive organs. Bread made
greeable taste, of rather more porous texture than ordinary baker's bread,
from sourness.

oubtless many other mineral substances which would act in the same way
ne-water. Thus sulphate of copper acts very powerfully in opposing
diastase, and is said to have been used for that purpose in Belgium, an
alt being dissolved in about a quart of water, and a wine-glassful of this
d with the water necessary for fifty quartern or four-pound loaves. This
tremely small; nevertheless the use of so poisonous a substance as sul-
er cannot be too strongly condemned: bread containing copper would be
juriously in the long run.

Mineral substances added to bread may be detected and estimated i the ordinary processes of inorganic analysis. A few details may, howev relating to the detection and estimation of alumina. The bread taken for should be crumb, from the middle of the loaf; it should be carefully tr crust and outside crumb, as those portions may be dirty. It is then to be a platinum tray; the charcoal reduced to powder and incinerated in a muf the ash digested in pure strong hydrochloric acid; the filtered solution e dryness to render silica insoluble; the dried residue drenched with strong acid, then boiled with water, and the liquid filtered. The acid filtrate m nearly neutralised with carbonate of sodium, pure alcoholic potash adde which will precipitate earthy phosphates and retain alumina in soluti liquid boiled and filtered; aqueous potash must not be used, as it alw alumina. The alkaline filtrate is then to be slightly supersaturated with acid and boiled with carbonate of ammonium; this will precipitate all t which may then be collected, dried, and tested with nitrate of cobalt befo pipe. (See p. 155.)

If a quantitative determination is to be made, it must be remember alumina precipitate generally contains phosphoric acid. To estimate th this acid, the precipitate, after being weighed, is to be dissolved in hydro the solution mixed with tartaric acid, excess of ammonia added (which no precipitate), and then sulphate of magnesium. The phosphoric acid be precipitated as ammonio-magnesian phosphate, which is converted by pyrophosphate of magnesium, $Mg^2P^2O^7$, whence the quantity of phosphor (P^2O^5) may be calculated, and this, deducted from the total weight of precipitate, gives the quantity of alumina. Or the precipitated alumina phosphate may be dissolved in nitric acid, a piece of metallic tin added, a boiled: the tin is thereby oxidised, and remains as an insoluble powde of stannic oxide and phosphate, the whole of the phosphoric acid being th from the alumina. The whole is next evaporated to dryness, the residue water and filtered, and the alumina precipitated from the filtrate by ammonia.

UNFERMENTED BREAD.—Instead of using alum or other mineral su above described, to counteract the injurious secondary actions which take the fermentation of dough, methods have been proposed, and to a certain ex out, for dispensing with the fermentation altogether, and supplying the c which is to give lightness to the dough, from some extraneous source.

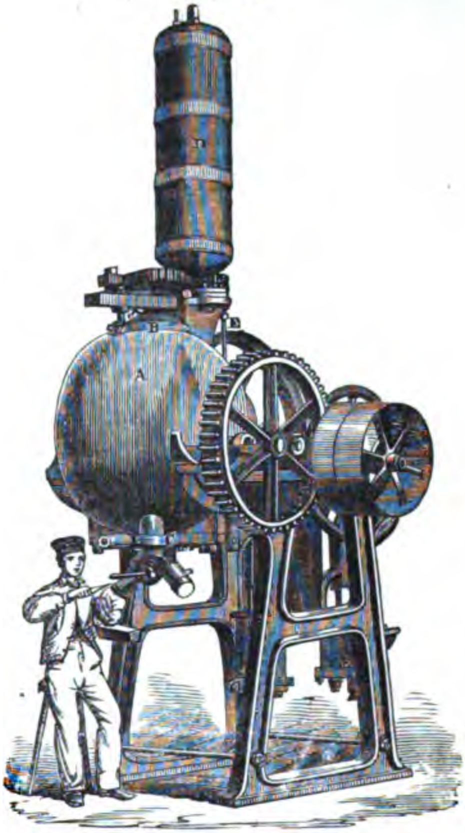
1. Instead of mixing salt (chloride of sodium) with the flour and water, acid and carbonate of soda are added in the proportion required to form sodium, the carbonic acid thereby evolved causing the dough to rise just been generated by fermentation. Bread thus made is said to be of g though it is never so white as ordinary baker's bread. There is, howeve objection to its constant use, namely, that it is liable to be contaminated introduced by the hydrochloric acid. That acid indeed, as found in comm contains arsenic, the complete removal of which can only be effected by a p too costly and troublesome for the purposes of a bake-house; and though of arsenic actually present in the bread may be small, still by daily use it mulate in the system and ultimately produce injurious effects.

2. *Preparation of* AËRATED BREAD.—Carbonic acid gas produced from by the action of dilute sulphuric acid or by ignition, and stored in an o holder, is pumped therefrom into a cylindrical vessel containing water, water becomes charged with the gas. This carbonic acid water is mixed sure with the flour, and the resulting dough, which becomes vesicular on of the pressure, is divided into loaves and baked. This process, which and patented by Dr. Dauglish, has been carried out on a large scale in other places.

The following is a description of the apparatus:—A (*fig.* 112) is the mi in which the flour, water, and salt are mixed together. It consists of a iron spheroïdal vessel, with an internal capacity of from 17 to 20 cubic f an opening B at the top, to which an air-tight cover is fitted, and the mea it to resist considerable pressure. There is also a corresponding opening C at large enough for a man-hole, and also closed by a lid, to which is attach ratus for drawing off the dough through suitable mouthpieces in a contin which is cut into pieces by a boy, and received into boxes or baskets to to the oven. Through the centre of the mixer, a shaft passes furnished boxes, to prevent the escape of compressed gas, and in this shaft suitable are fixed: by means of the necessary gearing this shaft is made to rota power. D is a copper water-vessel, having communication with the mi

s of a valve, and from the top by means of a pipe passing up inside
l. This water-vessel has also communication with a pair of condensing
are fixed in the
hind the mixer,
by a steam en-
munication is by
ipe E, which ter-
the water-vessel
ated with minute

Fig. 112.



apparatus, the
f the mixer is
bout 560 lbs. of
t into it by
pper and shoot
the floor above;
mount of 30 gal-
drawn into the
m a cistern above,
is then closed,
the flour the ne-
After removing
e apparatus by a
, carbonic acid
the condensing
s-holder, in which
il it is condensed
tmospheres. This
being dispersed by
e bottom of the
passes in minute
h the water, and
within increases,
bs the gas in pro-
which is not ab-
down the internal
top of the water-
e mixer, so that
ithin that vessel
librium with that
essel. When the
is attained, the
bottom of the
opened, when the
on the flour, after
ng arms are set to work, and in about six minutes the dough is thoroughly
allowed to subside for a minute, and is then drawn off through the
tus, being forced through it by the elastic force of the gas within.
rom the condensed atmosphere in the mixer, the dough immediately
esicular form and texture, and is ready to be baked.

c acid is obtained by acting on whiting or ground chalk with sulphuric
s off perfectly pure, and, being kept over water, is thoroughly washed.
20 cubic feet of carbonic acid at atmospheric density to prepare dough
of flour, about 11 cubic feet being incorporated with the dough, the re-
ic feet being wasted in the operation of drawing the dough off, and in
7 lbs. of sulphuric acid give, in practical working, 21 cubic feet of
from 10 lbs. of carbonate of lime, the sulphuric acid being of density of
gas which is left in the apparatus after the dough is discharged, is re-
gas-holder for further use.

ages of this process are thus stated by Dr. Odling in a paper read before
Section of the British Association at Aberdeen in 1859:—1st. Its
nstead of the dough being mixed with the naked arms or feet, the
he wetting of the flour to the completion of the baking, is not, and
e, touched by any one. 2nd. Its rapidity. An hour and a half serves
onversion of a sack of flour into baked loaves; whereas, in the ordinary
r five hours are occupied in the formation of the sponge, and a further time
g, raising, and baking of the dough. 3rd. Its preventing the glucogenic

deterioration of the flour, which takes place in the ordinary process (p. 657), an
obviating the necessity of using alum. 4th. Its certainty and uniformity.
differences in the character and rapidity of the fermentation, dependent on v
of temperature, quality of yeast, &c., the manufacture of fermented bread f
presents certain vagaries and irregularities from which the new process is ent
5th. The character of the bread. Chemical analysis shows that the flour h
gone less deterioration in bread made by the new than in that made by the f
process. In other words, the percentage of extractive matters is smaller.
bread has been tried dietetically at Guy's Hospital, and by many London p
and has been highly approved of. It is well known that, for some years pas
of fermented bread in dyspeptic cases has been objected to by members of th
profession, the débris of the yeast being considered unwholesome, and liable
acidity. 6th. Its economy. The cost of carbonic acid is alleged to be less
cost of yeast. Moreover, in making fermented bread, there is a small but
waste of the saccharine constituents, which is avoided in the new process.
saving of labour and health. It substitutes machine labour for manual la
very exhausting kind. The sanitary condition of journeymen bakers was inv
some time ago by Dr. Guy, and found to be most lamentable, from their
night work, and from the fatiguing and unwholesome character of their lab
ticularly the kneading. In a politico-economical point of view, the proce
important, as removing bread-making from a domestic manual work to a manu
machine work. From the character of the apparatus, the process can only
profitably on a large scale, and not in small bakeries.

Of all the advantages just noticed, the most important is the prevention c
terioration of the flour, which is so apt to occur in the ordinary process
making. We have already observed (p. 657) that this deterioration consist
great conversion of the starch into dextrin and sugar, and that it takes pl
greatest extent when flour is used which contains the external as well as t
portions of the wheat-grain, because the external portions are rich in n
matter,—the central consisting almost wholly of starch,—and a portion of th
passing into a metamorphic state (diastase or cerealin) and acting as a
produces the change just mentioned. Now it is important that this exte
genous portion of the grain should be retained—especially for persons w
little meat, and to whom bread is essentially the staff of life,—both for
nutritive power, and for the part which the metamorphic gluten undoubtedl
assisting the solution of the starch and unaltered gluten in the process of
In this country, however, there is an almost universal preference for white
consequently the miller contrives so to grind and dress his flour as to get ri
possible of the nitrogenous portion, and thereby prevent the conversion of
into dextrin and sugar during fermentation, which, as already observed, is
cause of the loss of whiteness. Hence it is, perhaps, as Dr. Dauglish sug
wheaten bread has not hitherto entered so extensively into the diet of the
in England as oatmeal in Scotland. The latter is prepared for food by simp
it in water in the form of a porridge, so that all the elements are present
system uninjured by artificial processes, whereas our wheaten bread is generall
in such a manner as to rob it of certain of those constituents which not only
themselves great nutritive power, but likewise materially facilitate the diges
whole. Now the new method of bread-making renders it possible to retain
matters, and at the same time to produce a light crumbly loaf, without the u
or any other mineral ingredient. (See a paper by Dr. Dauglish read before t
of Arts, 25 April, 1860; also "On Fermented Bread and Aërated Bread,"
Times and Gazette, 12 May, 1860.)

For further details on the making of bread, and for descriptions and
kneading machinery and patent ovens, see the article BREAD in *Ure's Dict*
Arts, Manufactures, and Mines, i. 400; *Muspratt's Chemistry*, i. 353; Pay
de Chimie Industrielle, 4me éd. ii. 126; *Handwörterbuch d. Chem.* 4te Aufl. i
On the composition of wheat-grain, flour, and bread, see Lawes and Gilber
Soc. Qu. J. x. 1, 269.)

BREAN. See ICICA RESIN.

BREIDIN and **BREIN.** See ARBOL-A-BREA.

BREISLAKITE. A mineral occurring in cavities of Vesuvian lava, in
crystals. Chapman (Phil. Mag. [3] xxxvii. 444) regards it as a variety
The form is that of basaltic augite. Colour brownish or grey with metallic lust
before the blowpipe to a shining magnetic bead. Not attacked by boiling hydroch

BREITHAUPTITE. Native antimonide of nickel, Ni^2Sb^2 (p. 316).

GREEN. A green pigment consisting chiefly of basic carbonate of
vith alumina and carbonate of calcium. According to Bley, a fine blue-
obtained by dissolving commercial sulphate of copper in 10 pts. of
little nitric acid, leaving the liquid to itself for a week, then filtering,
ne-water, precipitating with filtered solution of pearl-ash, and mixing
cipitate with gum-water to give it lustre.

ITE. See MAGNESITE.

TE. See NATROLITE.

RITE. A somewhat rare mineral, occurring in transparent colourless
als, of the monoclinic system, with the lateral faces inclined to the ter-
an angle of 93° 40′. Specific gravity 2·12 to 2·2 (Brewster); 2·453
ardness = 5·0 to 5·5. According to the following analyses by Connell
. xiv. 35), Thomson (Mineralogy, i. 348), and Mallet (Sill. Am. J.
, it is of the form $M''O.Al^2O^3.6SiO^3 + 5H^2O$, the symbol M'' denoting
ium, and calcium in the atomic proportion Sr : Ba : Ca = 4 : 2 : 1, and
he water as basic and substituting $al'' = 18{\cdot}3$ for $Al = 27{\cdot}4$, the for-
educed to $M''al^2H^{10}Si^6O^{21}$, which is of the form $R^6Si^2O^7$ or $R^4SiO^4.R^2SiO^3$:

Al^2O^3	$Ba''O$	$Sr''O$	$Ca''O$	H^2O	Fe^2O^3	
7·49	6·75	8·32	1·35	12·58	0·29	= 100·45 (Connell)
6·54	6·02	9·01	0·80	14·73	—	= 100·17 (Thomson)
5·25	6·80	8·99	1·19	13·22	trace	= 97·87 (Mallet)

pipe, it parts with its water and becomes opaque, then froths, and swells
vith difficulty. Leaves a silica skeleton when fused with phosphorus-
s in acids, with separation of silica. It occurs at Strontian in Argyleshire,
s Causeway, in the lead mines at St. Turpet near Freiburg, in the
ne department of Isère in France, and in the Pyrenees.

OLIN. A liquid hydrocarbon found in minute cavities in crystals of
eryl, quartz from Quebec, and amethyst from Siberia, in which it was
D. Brewster. It is transparent and colourless, and is nearly thirty-two
sible by heat as water, increasing one-fourth of its volume by an incre-
at 50° F. On exposure to the air, it undergoes quick motions and
nally evaporates, leaving a residue of minute solid particles, which, from
f the hand alone, suddenly become fluid again. The residue volatilises
issolves in acids without efflorescence. (Dana, ii. 471.)

Common bricks are made with clay mixed with sand or ashes, and
t at various temperatures. In some southern countries, bricks are merely
un, but they then remain very friable, and are fit only for light con-
early all sedimentary or alluvial formations contain clays which may be
g bricks. Some clays do not require any addition of sand, but with
n admixture of sand is necessary. In this country, coal-ashes are mixed
partly to give it the right consistence, partly to facilitate the burning.
g up and turned over in the winter, and being thus exposed to wet
reaks up and mixes better with the coal-ashes which are afterwards
tiff clays, 50 chaldrons of ashes are added to 240 cubic yards of clay;
ining much sand, 40 chaldrons of ashes to 220 cubic yards of clay, and
es make 100,000 bricks. The clay and ashes are mixed with water and
corporated, first by raking and afterwards in the *pug-mill*, which is an
rrel, in the centre of which is a vertical shaft, worked by a horse, and
ives, all of which, except the top one, are furnished with teeth. At the
barrel, is a small hole, through which the masticated clay is forced by
of the teeth. The clay is next fashioned into bricks in rectangular
ls, previously sanded. The bricks are then dried in the air, and after-
p into heaps called *clamps*, having flues or spaces left in them, which are
y wood, on which is put a covering of *breeze*, a coarse kind of coal-ash
sifting. The clamp when full is surrounded with old bricks, and on the
ick layer of breeze is laid. The external bricks at the sides are coated
astering of clay, to exclude the air, and in wet weather protected by
g rushes woven into them. The fire is lighted at the mouths of the
f it burns well, are then stopped up. In favourable weather, the bricks
bout twenty-five or thirty days. In this mode of burning, the coal-ashes
in the substance of the bricks contribute greatly towards the effect.
owever, bricks are burned in kilns, and then they have no ashes mixed
e firing being wholly external.

are bricks made of refractory clay, that is of clay which will stand a

very strong heat without fusing. Such clays must be free from lime and
iron. The clay of Stourbridge in Worcestershire, and those of Burgundy
brated for their fire-resisting qualities, and are therefore used for making b
lining furnaces. The clay is mixed with sand or with the fragments of
bricks ground to powder. (See *Ure's Dictionary of Arts, Manufactures, an*
i. 441.)

BRICKS (FLOATING). Bricks that swim on water were manufacture
ancients; and Fabbroni discovered some years since, a substance, at Castel d
near Santa Fiora, between Tuscany and the States of the Church, from which
bricks might be made. It constitutes a brown earthy bed, mixed with the re
plants. Haüy calls it *talc pulvérulent silicifère*, and Brochant considers it as
of *meerschaum*. The Germans name it *Bergmehl* (mountain meal), and the
latte di luna (moon milk). According to Klaproth's analysis, it consists of
5 alumina, 3 oxide of iron, 12 water, and 1 loss, in 100 pts. It agrees nearly
position with *Kieselguhr*.

BRILLIANT. Diamond cut in such a way as to reflect light most
called a brilliant. (See DIAMOND.)

BRIMSTONE. See SULPHUR.

BRINDONIA INDICA. A plant belonging to the order *Guttifer*
pericarp of the fruit is used in Goa as a spice, and the blood-red acid ju
lemonade. The seeds are convex, red-brown, tasteless, of the size of ordina
and contain 1·72 per cent. nitrogen, or after removal of the fat, 2·58 per cent.
dry state, they do not yield any fat by pressure, requiring to be previously sof
vapour of water; by the use of solvents, 30 per cent. of fat may be extract
crude fat is nearly colourless, melts at 40° C., dissolves sparingly in hot alc
easily saponifies, yielding glycerin, together with oleic and stearic acids, t
amounting to 50 per cent. From the crude fat, pure stearic is easily obtained
tallisation and pressing out the mother-liquor. The red-brown cake left
hausting the fat with ether, contains a fine red colouring matter, soluble in
alcohol, insoluble in ether and in acids. (J. Bouis and D'Oliveira Pi
Compt. rend. xliv. 1355.)

BRITANNIA METAL. An alloy of tin and antimony. (See TIN.)

BRITHYNE. Syn. with GLAUBERITE.—**BRITISH GUM.** See D

BRITTLE SILVER ORE. Native sulphide of silver. See SILVER.

BROCATELLO. A calcareous stone or marble, composed of fragmen
colours. white, yellow grey, and red.

BROCCOLI. See BRASSICA.

BROCHANTITE. A basic sulphate of copper, $Cu''SO^4.3Cu''H^2O^2$, fou
associated with malachite and red copper ore, at Ekatherinenburg in Siberi
Rezbanya in Hungary. Small right rhombic prisms of 117°. Emerald-gre
parent, with glassy lustre; harder than calcspar. Specific gravity 3·80—3·8
before the blowpipe, and forms a bead of reduced copper or charcoal.

BRODDBO TANTALITE. See TANTALITE.

BROGNIARDITE. A sulphantimonite of lead and silver, $Pb''Ag^2S^2$.S
Mexico. It occurs in masses without cleavage. Lustre metallic. Streak
black. It is rapidly attacked by strong nitric acid. An analysis by Damo
Min. [4] xvi. 227) gave 19·38 per cent. S, 29·95 Sb, 25·03 Ag, 24·74 Pb, 0·5
0·04 Zn.

BROGNIARTIN or **BROGNIARTITE.** Syn. with GLAUBERITE.

BROMACETIC ACID, $C^2H^3BrO^2$.—(W. H. Perkin and B. F. Dupp
Soc. Qu. J. xi. 22.)

Formation.—By the action of bromine on acetic acid:—

$$C^2H^4O^2 + Br^2 = C^2H^3BrO^2 + HBr.$$

A small quantity of dibromacetic acid is formed at the same time.

Preparation.—A mixture of glacial acetic acid and bromine in equal n
atoms (an excess of acetic acid being used to absorb the hydrobromic acid an
diminish the pressure) is introduced into a strong sealed tube, and heated i
bath to 150° C., and the bath is then left to cool gradually. When the temper
fallen to about 146°, the mixture suddenly becomes nearly colourless, or ligh
brown, and at the same time, the tubes are apt to burst, though the tempe
the bath may have risen as high as 155°. The tube when quite cold is
torrents of hydrobromic acid gas then escaping; the contents are transfer
retort provided with proper apparatus for condensing the hydrobromic a

200°; and the retort is left to cool. The whole contents then solidify
ile into a beautifully crystalline mass, consisting of bromacetic and dibro-
ids, mixed with a little hydrobromic acid, to remove which the mixture
o 130°, and carbonic acid gas passed through it till the presence of hydro-
d is no longer indicated by nitrate of silver. Carbonate of lead is then
xcess, together with a volume of water about ten times as great as that of
and the whole is heated to 100°, and allowed to stand for some hours.
te of lead then crystallises out, while dibromacetate remains in solution.
ls may be freed from the last portions of this salt by washing with a little
Lastly, the crystals of bromacetate of lead are suspended in water and
l by sulphuretted hydrogen, and the filtered liquid is evaporated till it

tic acid forms rhombohedral crystals which are very deliquescent. It melts
C., and boils at 208°; attacks the skin powerfully, raising a blister like a
n the acid is dilute, this effect takes place after eight or ten hours only. It
ble in water.
l strongly heated in a sealed tube, is resolved into dibromacetic acid,
ide, and apparently marsh-gas, together with water and hydrobromic acid,
represented by the equation:

$$3C^2H^3BrO^2 = C^2H^2Br^2O^2 + 3CO + CH^4 + HBr + H^2O.$$

lling it with acetate of potassium, acetic acid is evolved.—Heated with
nc, it yields acetate and bromide of zinc.—Heated with ammonia, it forms
ammonium and glycocine:

$$C^2H^3BrO^2 + 2NH^3 = NH^4Br + C^2H^5NO^2.$$

is monobasic, the formula of its salts being $C^2H^2BrO^2.M$. Most of them
lisable and many of them decompose rapidly.

tate of Ammonium.—Nearly uncrystallisable; very soluble in water; de-
hen heated, yielding bromide of ammonium.

tate of Barium crystallises with difficulty in small stars containing water
sation; it is tolerably soluble in alcohol.

tate of Calcium is a very difficultly crystallisable salt, very soluble in water.

tate of Copper is a green crystalline salt, very soluble in water. A
it appears to decompose when boiled, as the colour becomes paler. The
fter standing for some days, deposits needle-shaped crystals and small mala-
tufts of great beauty, which appear to contain a large quantity of water of
ion.

tate of Lead.—Obtained, either by neutralising bromacetic acid with oxide
l recrystallising the product from water; or by adding a solution of brom-
to a solution of acetate of lead, washing the resulting crystalline precipitate
water, and recrystallising from water. Crystallises in needles, sparingly
cold, but moderately soluble in hot water.

tate of Potassium.—Obtained by neutralising a solution of carbonate or
potassium with bromacetic acid, and evaporating the solution in a water-
s a crystalline salt, very soluble in water and alcohol.

tate of Silver. $C^2H^2BrAgO^2$.—Obtained by treating bromacetic acid
onate of silver, or by adding a solution of bromacetic acid to a solution of
ilver. In the latter case, it is thrown down as a beautiful crystalline pre-
hich may be washed with cold water, and dried over sulphuric acid in vacuo.
3·62 per cent. silver (by calculation, 43·9). It is very unstable. The dry
to about 90° C., decomposes with a sort of an explosion. It is rapidly acted
ht when moist. Boiled with water, it yields bromide of silver and glycollic

$$C^2H^2BrAgO^2 + H^2O = AgBr + C^2H^4O^3.$$

tate of Sodium is very soluble in water, but insoluble, or nearly so, in

ETIC ETHERS.—*Bromacetate of Methyl*, $C^3H^5BrO^2 = C^2H^2BrO^2.CH^3$, is ob-
heating amixture of methylic alcohol and bromacetic acid in a sealed tube
, to a temperature of 100° C., washing the product with water, drying over
calcium, and rectifying. It is a transparent, colourless, mobile liquid, having
c odour highly irritating to the nose and eyes. It is heavier than water;
out 144° C., decomposing gradually every time it is distilled. Ammonia acts
readily.

tate of Ethyl. $C^4H^7BrO^2 = C^2H^2BrO^2.C^2H^5$.—Obtained in a similar
the preceding. It is a clear colourless liquid, heavier than water, and

highly irritating to the eyes and nose. It boils at 159° C. Decomposes partiall time it is distilled, with evolution of hydrobromic acid. It is rapidly acted ammonia.

Bromacetate of Amyl. $C^7H^{13}BrO^2 = C^2H^2BrO^2.C^5H^{11}$.—Obtained by heating alcohol with excess of bromacetic acid, washing the product with water, and over chloride of calcium. It is an oily liquid which has a pleasant odour wh but if heated, acts upon the eyes and nose like the preceding. It boils at 207° decomposes partially every time it is distilled. Ammonia acts but slowly up the cold.

The bromacetates of methyl, ethyl, and amyl, boil at temperatures about 82° higher than the acetates. Thus—

	Boiling-point.		Boiling-point.	I
Bromacetate of Methyl .	144° C.	Acetate of Methyl .	58° C.	8
„ Ethyl .	159°	„ Ethyl .	74°	8
„ Amyl .	207°	„ Amyl .	125°	8

A similar difference exists between the boiling points of bromacetic acid (20 acetic acid (120°).

Dibromacetic Acid. $C^2H^2Br^2O^2$. (Perkin and Duppa, Chem. Soc. Qu. —Formed, together with monobromacetic acid, when a mixture of bromine ar acid is exposed to light (p. 663). To obtain it in quantity, the monobromina is exposed to the action of bromine-vapour in strong sunshine. The product freed from hydrobromic acid by passing a stream of dry carbonic acid gas th at 120° C.

It is a colourless, inodorous liquid, of specific gravity 2·25; it was once, dur cold weather, obtained in fine needle-shaped crystals. When placed on the produces painful blisters like burns. It boils between 225° and 230° C., but c distilled without decomposition. It dissolves readily in water, producing co in alcohol and ether. Zinc decomposes it, with evolution of hydrogen.

Dibromacetate of Ammonium. $C^2H^2Br^2O^2.NH^4 + \frac{1}{2}aq.$—Obtained by neutral acid with dilute ammonia and leaving the solution to evaporate, either in or over sulphuric acid in vacuo. Forms splendid crystals, which give off the at 100°, becoming white and opaque. Heated to 100° C. with excess of ammo decomposed, giving off volatile products, which have not yet been examined. solves readily in water, alcohol, and ether.

Dibromacetate of Potassium is a beautifully crystalline salt, shooting long and very brilliant crystals, containing water of crystallisation; very s alcohol and water, but not deliquescent.

Dibromacetate of Lead is a very soluble and uncrystallisable substance, d to a tough gum-like mass. When added to water in excess, it fuses and ru like a heavy oil; it is formed by adding the acetate or carbonate of lead to acetic acid.

Mercurous Dibromacetate is precipitated on adding a solution of mercurou to dibromacetic acid; it much resembles dibromacetate of silver, and like it u decomposition when boiled.

Dibromacetate of Silver is formed by adding the carbonate or nitrate to dibromacetic acid; it crystallises in small needles, often grouped in st the acid is dilute. It is easily decomposed at 100° C. yielding bromide of s bromoglycollic acid:

$$\underset{\text{Dibromacetate of silver.}}{C^2HBr^2O.Ag.O} + H^2O = \underset{\text{Bromoglycollic acid.}}{C^2HBrO.H^2.O^2} + AgBr.$$

Dibromacetic acid heated with *ethylic* and *amylic alcohols*, yields the corre ethers. The ethyl-compound is decomposed by ammonia, yielding alc dibromacetamide:

$$C^2HBr^2.C^2H^5.O^2 + NH^3 = C^2H^5.H.O + N.H^2.C^2HBr^2O.$$

BROMACETINS. See ACETINS.

BROMAL. *Hydride of Tribromacetyl. Oxide de Bromêthile.* $C^2HBr^3O = C$ (Löwig, Ann. Ch. Pharm. iii. 228.)—A compound analogous to chloral, and in like manner, by the action of bromine on alcohol. 3 or 4 pts. by weight of are gradually added to 1 pt. of absolute alcohol, cooled by ice; the mixture i itself for ten or twelve days, and then distilled; and after three-fourths (cons hydrobromic acid, bromide of ethyl, and other products) have passed over, the is mixed with water, and exposed to the air for a day or more in a shallow ba then deposits large crystals of hydrate of bromal, which yield the anhydrous co by distillation with sulphuric acid. Or they may be gently heated with six tim

? strong sulphuric acid, and the anhydrous bromal, which then sinks to the s a colourless oil, may be separated by decantation and distilled, first over d then over quick lime.

l is said to be also produced by the action of bromine on a mixture of alcohol c acid. (Aimé.)

l is a transparent colourless oil, of specific gravity 3·34. It is somewhat greasy uch, and makes grease-spots upon paper, which however soon disappear. Its oint is above 100° C. and it may be distilled without decomposition. It has a pungent odour, and excites a copious flow of tears. Its taste is extremely l burning, and very persistent.

l is decomposed by aqueous alkalis in the same manner as chloral, yielding m, $CHBr^3$, and a formate of the alkali-metal. Lime and baryta heated in its ecome incandescent, and decompose it, yielding carbonic oxide, water, and e of the metal mixed with charcoal. Red-hot iron acts in a similar manner. decomposed by nitric acid, sulphuric acid, or chlorine.

te of Bromal. $C^3HBr^3O.2H^2O$. — Bromal dissolves in a small quantity of d the solution, when left to evaporate, yields the hydrate in large crystals, ne form of sulphate of copper. They melt at the heat of the hand, dissolve n water, and yield anhydrous bromal when treated with sulphuric acid. The s also formed when bromal is exposed to moist air.

l dissolves sulphur and phosphorus, and mixes readily with bromine, also with nd ether.

MALOÏN. See ALOIN (p. 148).

MAMIDE. See NITROGEN, BROMIDE OF.

MANIL. Syn. of PERBROMOQUINONE. See QUINONE.

MANILAMIC ACID. BROMANILIC ACID. BROMANILA- Syn. with DIBROMOQUINONAMIC ACID, DIBROMOQUINONIC ACID, and DIBRO-NAMIDE. (See QUINONIC ACID.)

MANILOIDE. See TRIBROMOPHENYLAMINE, under PHENYLAMINE.

MANISIC ACID. See ANISIC ACID.—**BROMANISOL.** See ANISOL.

MARGYRITE. Native bromide of silver. (See SILVER.)

ZEIN. $C^{10}H^6Br^4$?—A crystalline product, obtained in small quantity by n of bromine on crude benzene. (Laurent.)

ETHERIDE, BROMETHERIN, BROMETHEROIDE. See VINYL, OF.

ETHIONESSIL. A product of the action of bromine on thionessal (*q. v.*) colourless tables, apparently consisting of $C^{28}H^{14}Br^4S$. (Laurent.)

MHYDRIC ACID. See BROMIDE OF HYDROGEN.

MHYDRINS. (Berthelot and De Luca, Ann. Ch Phys. [3] xlviii. 304; —These compounds are produced by the action of tribromide or pentabromide horus on glycerin. Their composition is such as might result from the com- of glycerin and hydrobromic acid, with elimination of water, and may be ted empirically by the general formula

$$m\ C^3H^8O^3 + n\ HBr - p\ H^2O.$$

names and formulæ are as follows:

Monobromhydrin . .	$C^3H^7BrO^2 = C^3H^8O^3 + HBr - H^2O$
Epibromhydrin . .	$C^3H^5BrO = C^3H^8O^3 + HBr - 2H^2O$
Dibromhydrin . .	$C^3H^6Br^2O = C^3H^8O^3 + 2HBr - 2H^2O$
Tribromhydrin . .	$C^3H^5Br^3 = C^3H^8O^3 + 3HBr - 3H^2O$
Hemibromhydrin . .	$C^6H^9BrO^2 = 2C^3H^8O^3 + HBr - 4H^2O$
Hexaglyceric Bromhydrin	$C^{18}H^{27}BrO^7 = 6C^3H^8O^3 + HBr - 11H^2O$

-, di-, and tribromhydrin, may also be regarded as glycerin, $C^3H^5(HO)^3$, in or more at. of peroxide of hydrogen has been replaced by bromine.

es these compounds, there are formed at the same time others of similar nature, ve not been examined; likewise acrolein, and dibromallylphosphine, $C^6H^9Br^2P =$ $H^4Br)^2$.

romhydrins heated with aqueous potash to 100° C., in closed vessels, all yield of potassium and glycerin.

ration of the Bromhydrins.—500 grms. of glycerin are added by small por- between 500 and 600 grms. of liquid bromide of phosphorus, the liquid being fter each addition, and the mixture, after standing for twenty-four hours, is into a well-cooled receiver communicating with a vessel containing potash-ley, to absorb the acrolein vapour. As an additional precaution against the inj of this vapour, the distillation and all the subsequent operations should l either in the open air, or under a chimney with a good draught.

The distillate, consisting of an upper watery layer and a lower liquid water, may be freed from part of the acrolein by heating it in the water- then mixed with potash in sufficient quantity to supersaturate the acid the acrolein, and the watery layer is separated from the lower liquid.

The watery liquid is then treated with ether, whereby an ethereal so tained, which, when quickly evaporated, leaves a residue chiefly consisting volatile products of the reaction, together with *epibromhydrin.* The l which is insoluble in water and requires to be treated for several hours w potash, consists chiefly of *epibromhydrin* and *dibromhydrin.* The resid mains in the retort after the distillation, is suspended in water, supersat carbonate of potassium, and shaken up with ether, and the filtered eth are evaporated: they then leave a mixture of *dibromhydrin, monobrom* several other substances.

To separate the individual substances contained in these several mixtu tures are subjected to repeated fractional distillation, and the portion wh volatilise at 240° C. under the ordinary atmospheric pressure, is fraction under diminished pressure (about 10mm. of mercury). The distillate t between 120° and 160° consists chiefly of dibromhydrin; between 160° a compound $C^6H^9Br^2P$ passes over together with monobromhydrin, and b and 300°, syrupy liquids which cannot be further separated, but appear hydrins. In the retort there remains a thick syrup, together with a blac compound which is *hexaglyceric bromhydrin.*

Monobromhydrin, $C^3H^7BrO^2 = (C^3H^5)'''.(HO)^2.Br.$—This compound, over at 180° C. in the distillation under diminished pressure, is a neutra soluble in ether, and having a sharp aromatic taste.

Dibromhydrin, $C^3H^6Br^2O = (C^3H^5)'''.HO.Br^2.$—This, which is the of the action, is a neutral liquid, of specific gravity 2·11 at 18° C. boil having an ethereal odour, and soluble in ether. Heated with pentabrom phorus, it yields tribromhydrin. Heated to 140° with metallic tin, it is yielding bromide of tin and a tin-compound insoluble in water but solubl

When gaseous ammonia is passed into pure dibromhydrin, the lic hot, and yields bromide of ammonium, together with an amorphou $C^6H^{12}BrNO^2$, insoluble in water, ether, alcohol, and acetic acid:

$$2C^3H^6Br^2O + 4NH^3 = 3NH^4Br + C^6H^{12}BrNO^2;$$

but if the ammonia gas is passed into a solution of dibromhydrin in abs the products formed are bromide of ammonium and *hydrobromate of*

$$C^3H^6Br^2O + (NH^4)^2O = NH^4Br + C^3H^9NO^2.HBr.$$

Tribromhydrin. $C^3H^5Br^3$.—Obtained by distilling dibromhydrin hydrin with pentabromide of phosphorus, treating the product with wat and collecting apart that which passes over between 175° and 180° C. liquid, which fumes slightly in the air, is gradually decomposed by wat treated with moist oxide of silver, yields bromide of silver and gly isomeric with Wurtz's *tribromide of allyl* (called by Berthelot and De *bromhydrin*), and with *dibromide of bromotritylene,* $C^3H^5Br.Br^2$.

Epibromhydrin or *Oxybromide of Glyceryl.* C^3H^5BrO.—Th is produced in considerable quantity by the action of the bromides of p glycerin. It may be isolated by repeated fractional distillation, the portio at or near 138° C. being each time collected apart. It is a mobile ne soluble in ether, with an ethereal odour and pungent taste. Specific gra 14° C. Boils at 138°. Vapour-density, by experiment, 5·78. (This is above the calculated value, 4·80, probably because the density was taken ture too near the boiling point, viz. at 178°, the compound decomposin higher temperatures.)

This compound may be considered as deriving from tribromhydrin, by tion of O for Br^2. It is isomeric with *bromide of propionyl,* $C^3H^5O.Br.$ is also that of monobromhydrin *minus* H^2O, or of dibromhydrin *minus* H

Epibromhydrin, heated with aqueous potash to 100° for 112 hours, saponi bromide of potassium, glycerin, and a trace of matter soluble in ether. of silver decomposes it rapidly at 100°, forming bromide of silver and gl tilled with pentabromide of phosphorus, it is partly converted into tribro cording to the equation:

$$C^3H^5BrO + PBr^3Br^2 = PBr^3O + C^3H^5Br^3,$$

oes more complete decomposition, yielding a black substance and a
aining, in 100 volumes, 5·5 carbonic anhydride, 5·5 tritylene, 11·0
arbonic oxide.

romhydrin. $C^{18}H^{37}BrO^7$. — This compound remains in the
a black crystalline mass, impregnated with a syrupy liquid. It is
vith cold ether; boiling ether dissolves it slightly.

n. $C^6H^9BrO^2$. — This compound passes over in the fractional
epibromhydrin and dibromhydrin, viz. at 200° C. It is a neutral
r, and saponifiable by potash, yielding bromide of potassium, a sub-
r identical with glycerin, and a trace of matter soluble in ether.
compound are said to agree nearly with the above formula (no
Berthelot and De Luca's memoir), according to which it may be
from epibromhydrin, in the same manner as the latter from
abstraction of half the hydrobromic acid:

$$C^3H^6Br^2O - HBr = C^3H^5BrO:$$

$$2C^3H^5BrO - HBr = C^6H^9BrO^2.$$

nposition to iodhydrin.

. $HBrO^3$ or $H^2O.Br^2O^5$. — This acid is produced: 1. By the
alkalis or alkaline earths:

$$6Br + 3K^2O = KBrO^3 + 5KBr.$$

rated from the bromide by its inferior solubility. A similar re-
th trioxide of gold, the products being bromate and bromide of

$$18Br + 3Au^2O^3 = \left.\begin{matrix}(BrO^2)^3\\ Au'''\end{matrix}\right\}O^3 + 5AuBr^3.$$

ion of pentachloride of bromine by water or by alkalis:

$$BrCl^5 + 3H^2O = HBrO^3 + 5HCl.$$

acid (bromate of hydrogen) the barium-salt is decomposed with
t quantity of dilute sulphuric acid, and the filtrate concentrated
gentle heat. It cannot, however, be reduced to a syrupy con-
mposition. The solution is colourless, acid to the taste, reddens
aches it. It is decomposed at 100° C., giving off bromine and
g agents decompose it with facility. With *sulphurous acid* the
e and sulphuric acid; with *sulphydric acid*, water, bromine, and
odic acid, water and bromide of iodine; with *hydrochloric acid*,
f bromine; with *hydrobromic acid*, water and bromine, *e.g.*:

$$HBrO^3 + 5HCl = 3H^2O + BrCl^5.$$

compose bromic acid, with formation of acetic acid and great rise

obasic, the formula of the Bromates being $MBrO^3$ or $M^2O.Br^2O^5$.
re soluble in water, though less so than the bromides. They may
ction of bromic acid on the oxides or carbonates of the metals, or
nate of barium with the corresponding sulphates; the bromates
also by treating the solutions of the alkalis with bromine-water or
nine, and crystallising out the sparingly soluble bromate from the
formed at the same time:

$$6KHO + Br^6 = KBrO^3 + 3H^2O + 5KBr$$
$$6KHO + BrCl^5 = KBrO^3 + 3H^2O + 5KCl.$$

most part crystallisable, but many of them decompose when their
; hence it is generally best to evaporate the solutions in vacuo or
The bromates of mercurosum, silver, and lead are insoluble.
o redness either give off their oxygen and leave bromides (K, Na,
e off bromine and part of their oxygen, and leave oxides, *e.g.*:

$$2ZnBrO^3 = Br^2 + O^5 + Zn^2O.$$

, sulphur, or other combustible substances, they explode by heat
olid bromates heated with *sulphuric acid*, give off bromine and
of a bromate is coloured red, even by dilute sulphuric acid. By
other reducing agents, they are decomposed in the same manner
tion of a bromate, not too dilute, gives with *lead-salts*, a white pre-

cipitate; with *mercurous salts*, a yellowish white precipitate, inso
acid; and with *silver-salts*, a white precipitate almost insoluble
soluble in nitric acid, easily in ammonia. This precipitate is
chloride of silver by giving off red vapours of bromine when he
acid. The reactions with silver-salts and with sulphuric acid di
from chlorates (*q. v.*)

Bromate of Aluminium.—Obtained as a clear, viscid, deliquescen
ing hydrate of aluminium in bromic acid, or by precipitating bro
with silicofluoride of aluminium, and evaporating the filtrate over s

Bromate of Ammonium. NH^4BrO^3.—White needles or crystall
rently belonging to the regular system. It cannot be preserved in
it decomposes after a while, with violent detonation, even at ordi
yielding nitrogen, bromine, oxygen, and water. Hydrochloric a
forming, however, but a small quantity of chloride of ammonium.

Bromate of Barium. $Ba''(BrO^3)^2$ + aq.—When bromine or chl
added to baryta-water till the colour begins to be permanent, bromate
lises out, while bromide or chloride remains in solution. But a bette
tion is to decompose 100 pts. bromate of potassium dissolved in
74 pts. crystallised chloride or 78 pts. anhydrous acetate of bari
liquid to cool slowly; the bromate of barium then separates out,
acetate of potassium remains in solution. Acetate of barium is
chloride for this preparation, on account of the greater solubility
potassium.

Bromate of barium forms a crystalline powder or thin prisms
system, with the faces ∞P . ∞P∞ . (∞P∞) . P∞ . oP . +P∞. −∞
faces, ∞P : ∞P = 82° 10′ ; (P∞) : (P∞) = 79° 5′; oP : ∞P∞
P∞ = 138°. The salt is isodimorphous with chlorate of barium
Pogg. Ann. xc. 16). It dissolves in 130 pts. of cold and 24 pts.
does not give off its water of crystallisation till heated above 200°
on red-hot coals, it detonates with a green light. When heated a
with evolution of light and heat, into bromide of barium and ox
forming a perbromate. Hydrochloric or moderately dilute sulphur
it with separation of chloride of bromine or free bromine; very di
separates undecomposed bromic acid.

Bromate of Bismuth.—When bromic acid is poured upon hyd
basic insoluble salt is formed, together with a small quantity of di
basic salt, $3Bi^2O^3.2Br^2O^5$ + 6aq., is a white amorphous powder.

Bromate of Cadmium. $Cd''(BrO^3)^2$ + aq.—Rhombic prisms of
four-sided summits and truncation of the acute lateral edges by
Soluble in 0·8 pts. cold water. Decomposed by heat, leaving oxide
with bromide.

Ammonio-bromide of Cadmium, $6NH^3.Cd''(BrO^3)^2$, is deposited fr
solution of bromide of cadmium evaporated over quick lime, as
powder, which gives off ammonia when heated, and is decomposed

Bromate of Calcium. $Ca''(BrO^3)^2$ + aq.—Monoclinic tables
prisms; ∞P : ∞P in the clino-diagonal section = 79° 56′; ∞P2 :
118° 22′; + P′ : + P in the same = 98° 41′ : − P : − P in the
(½P∞) : (½P∞) in the same = 123° 33′ (Rammelsberg). Dissol
rature in 1·1 pt. water, forming a syrupy solution. The crystals g
at 180° C.; at a stronger heat, oxygen is given off and bromide of

Bromate of Cerium. $Ce''(BrO^3)^2$ + aq.—Colourless laminæ, wh
in water, and do not effloresce over sulphuric acid.

Bromate of Chromium.—Chromic sulphate decomposed by b
yields a green filtrate, which decomposes by evaporation, givin
leaving a dark red residue, consisting almost wholly of chromic aci

Bromate of Cobalt. $Co''(BrO^3)^2$ + 6aq.—Hyacinth-red, transp
soluble in 2·2 pts. water; the solution is decomposed by heat.
heated leaves a residue of oxide of cobalt. The salt dissolves in
forming a red liquid which turns brown in the air, and yields, aft
brown crystals, probably consisting of the bromate of Frémy's *fus*

Bromate of Copper, $Cu''(BrO^3)^2$ + 5aq., crystallises from a conc
light-blue or blue-green crystals, which are very soluble in water,
the air, but crumble to a greenish-white powder in vacuo over sul
retain a small portion of their water even at 180° C., but give it o
with part of the bromine. The aqueous solution mixed with a lit

ne precipitate, consisting of a basic salt, $6Cu''O.Br^2O^5 + 10aq.$, which at 200° ts water and becomes greyish-green.

io-bromate of Copper, $4NH^3.Cu''(BrO^3)^2$, separates as a dark-blue crystalline adding alcohol to a solution of bromate of copper in excess of ammonia. It in a small quantity of water, and is decomposed by excess of water, with of a basic salt. When heated it decomposes with deflagration.

TES OF IRON.—A solution of ferric hydrate in bromic acid yields by evapora- sulphuric acid a syrup, which, after drying over the water-bath, leaves a e basic salt, $5Fe^2O^3.Br^2O^5 + 30aq.$, insoluble in water.

on of ferrous carbonate in bromic acid yields by evaporation in vacuo octa- ystals of *neutral ferrous bromate*, $Fe''(BrO^3)^2$, the solution of which easily s, with separation of the basic ferric salt.

TE OF LANTHANUM. $La''(BrO^3)^2 + 6aq.$—Amethyst-coloured crystals (? con- dymium), which give off 20 per cent. water at 160° C.

TE OF LEAD. $Pb''(BrO^3)^2 + aq.$—Obtained by precipitation, or better by dis- rbonate of lead in warm bromic acid; it then crystallises on cooling in small isms, isomorphous with the strontium salt. The crystals are permanent in d do not give off any water over sulphuric acid; they dissolve in 75 pts. ean temperature. The salt begins to give off oxygen and bromine at 180° C., antity of brown peroxide of lead being formed at the same time, whereas at heat, red lead or the yellow protoxide is formed; the residue contains prot- a small quantity of bromide.

TE OF LITHIUM, $LiBrO^3$, crystallises from a syrupy solution over sulphuric eedles, which effloresce in a dry atmosphere, but deliquesce when exposed to ir.

TE OF MAGNESIUM. $Mg''(BrO^3)^2 + 6aq.$—Large regular octahedrons, which 1·4 pts. water at 15° C.; melt in their water of crystallisation at a moderate off the greater part of it at 200° C.; and the last portion at a somewhat nperature, oxygen being at the same time evolved.

TE OF MANGANESE is formed by dissolving manganous oxide in bromic acid, poses very quickly.

TES OF MERCURY.—*The mercuric salt*, $Hg''(BrO^3)^2 + 2aq.$, is obtained by romic acid on recently precipitated mercuric oxide, as a white powder, which in 600 pts. of cold and 64 pts. boiling water. It dissolves also in excess of mic acid, and crystallises in small prisms on cooling. Hydrochloric acid it with decomposition. At 130°—140° C. it decomposes with detonation, a sublimate of mercurous and mercuric bromide, and a residue of mercuric t giving off part of the bromine and oxygen as gas. Ammonia added to aqueous solution throws down a compound of mercuric bromate with oxide urammonium, $Hg''(BrO^3)^2.(NH^2Hg'')^2O$, which does not yield any ammonia ted with potash. It is decomposed by heat with violent detonation.

ous bromate, $(Hg^2)''(BrO^3)^2$, is obtained as a white powder by precipitation, pletely saturating bromic acid with mercurous oxide. From a solution of the slight excess of bromic acid, it separates by evaporation in shining crystalline Water decomposes it, forming a basic salt, $(Hg^2)''O.(Hg^2)''(BrO^3)^2$. It es with detonation when heated.

TE OF NICKEL. $Ni''(BrO^3)^2 + 6aq.$—Green regular octahedrons having their eplaced by cube-faces. Thin plates cut parallel to the cube-faces act strongly ed light (Marbach, Pogg. Ann. xciv. 412). The salt gives off water when It dissolves in 3·6 pts. of cold water, also in ammonia, and on adding alcohol moniacal solution, a blue-green powder is precipitated, consisting of *ammonio- f nickel*, $2NH^3.Ni''(BrO^3)^2$, or *bromate of nickel-ammonium* $(N^2H^6Ni'')''(BrO^3)^2$.

TE OF PALLADIUM appears to be produced by dissolving palladous hydrate in id.

TE OF PLATINUM.—Platinic sulphate decomposed by bromate of barium ellow filtrate, which, when evaporated, gives off oxygen and bromine-vapour, sits platinic bromide.

TE OF POTASSIUM. $KBrO^3$.—Prepared by adding bromine to a warm, ly concentrated solution of potash, till the liquid acquires a permanent yel- t; the salt then separates almost completely on cooling, and may be purified nide of potassium by washing with water, and recrystallisation. It forms anhydrous crystals of specific gravity 3·271 (Kremers). From a hot solu- rystallises in needles, but by slow cooling it is obtained in four- and six- tes, or in cubes with rounded summits; by spontaneous evaporation in small sometimes in dendritic masses. According to Fritzsche, it always crystal-

lises in forms of the regular system; but, according to Rammels
hedrons, having the angles of the terminal edges = 86° 18′, and
therefrom. It dissolves in 32·1 pts. water at 0° C., in 18·5 pts. at 1
20°, in 7·5 pts. at 40°, in 4·4 pts. at 60°, in 2·9 pts. at 80°, and
(**Kremers**, Pogg. Ann. xcii. 497; xciv. 255; xcvii. 1; xcix. 25, 5
Pohl, 1 pt. of the salt dissolves in 17·5 pts. water at 17° C. The
from a solution, either perfectly neutral or slightly acidulated with
pitate with violence at 300°—350° C., and crumble to a powder,
into water, gives off bubbles of pure oxygen gas as it dissolves; but
evaporated yields nothing but pure bromate of potassium, probably
sorption of oxygen from the air. The crystals deposited from an
decrepitate but slightly when heated, and the powder dissolves in w
ceptible evolution of gas. (**Fritzsche**, J. pr. Ch. xxiv. 285.)

Bromate of potassium is decomposed by strong sulphuric acid, w
pitation and evolution of bromine and oxygen. When heated *per se*,
perature above 350° C., and then decomposes, with evolution of oxyg
but afterwards with explosive violence, beginning to glow at one
quickly becoming incandescent through the entire mass. When mi
tible bodies, it explodes with great violence when struck or heated.

Bromate of Silver. $AgBrO^3$.—Obtained by precipitation as an
powder quickly turning grey when exposed to light. According t
forms shining quadratic prisms (P : P in the terminal edges = 121°
edges = 86° 38), isomorphous with chlorate of silver. When rap
plodes with deflagration, giving off part of the bromine in the form
It dissolves sparingly in water and in nitric acid, more easily in amr
yielding by spontaneous evaporation, colourless prisms, which are qu
by water, and are very unstable even in the dry state.

Bromate of Strontium. $Sr''(BrO^3)^2$ + aq.—Small shining rh
with truncated lateral edges, isomorphous with the barium-salt.
1 : 1·1642 : 1·2292. Inclination of clino-diagonal to principal
crystals dissolve in 3 pts. of water at ordinary temperatures; do no
sulphuric acid, become anhydrous at 120° C., and at a higher tempe
resolved into oxygen gas and bromide of strontium.

Bromates of Tin.—*Stannic hydrate* unites slowly with bromic
after drying over oil of vitriol, a vitreous mass, which loses 18 per
180° C. *Stannous chloride* forms a white precipitate with bromate

Uranic Bromate.—A solution of uranic hydrate in bromic acid
tion over oil of vitriol, a yellow uncrystallisable syrup which decon
tion, giving off bromine and leaving a basic salt.

Bromate of Yttrium.—Sparingly soluble in water; remains in t
when its solution is evaporated.

Bromate of Zinc. $Zn''(BrO^3)^2$ + 6aq.—Regular octahedrons
faces; isomorphous with the magnesium-salt. It dissolves in 1 pt
temperatures, is permanent in the air, melts in its water of crystal
and becomes anhydrous at 200°, but undergoes decomposition
giving off bromine-vapour and oxygen, and leaving pulverulent o
salt is decomposed by a small quantity of ammonia, but dissolves c
of ammonia, the solution yielding by evaporation over hydrate of

Ammonio-bromate of zinc, or *bromate of zinc-ammonium*, N^2H^6Zn
small prismatic crystals, which when exposed to the air become mo
smell of free bromine. Water and alcohol decompose them with se
of zinc. At a gentle heat, the salt decomposes with a loud hissing
bromine together with nitrogen gas and water.

BROMIC SILVER. Native bromide of silver. (See Silve

BROMIDES. Compounds of bromine with electro-positive r
like chlorine, is monatomic, 1 at. of it being capable of uniting wit
or other monatomic radicle, 2 at. of bromine with 1 at. of a di
bromide of ethylene $(C^2H^4)''Br^2$, 3 at. of bromine with 1 at. of a tr
bromide of glyceryl $(C^3H^5)'''Br^3$. Bromine is less powerfully ele
chlorine; consequently bromides are for the most part decomposed

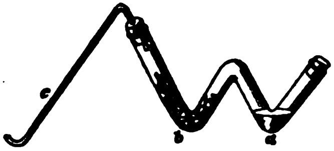
Bromide of Hydrogen. Hydrobromic or Bromhydric
compound is gaseous at ordinary temperatures, and is composed of
bromine-vapour and hydrogen united without condensation. It is
by the direct union of its elements. A mixture of hydrogen and br
not unite when exposed to the sun's rays; neither does it explode w

introduced into it; but combination takes place slowly in the
ood of the hot body, and more quickly when the mixture of
is passed through a red-hot tube, or when a platinum wire im-
d-hot by the electric current.
the action of water on tribromide of phosphorus:

$$PBr^3 + 3H^2O = H^3PO^3 + 3HBr.$$

mine are introduced into the bend *a* of the apparatus (*fig.* 113),
placed some small pieces
ed with water, and sepa-
s. The bromine at *a* is
rit-lamp, and the vapour
bromide of phosphorus,
y decomposed by the
horous acid, which re-
and hydrobromic acid,
gh the delivery-tube *c*,
over mercury.—2. By decomposing bromide of sodium or potas-
huric acid:

Fig. 113.



$$2NaBr + H^2SO^4 = Na^2SO^4 + 2HBr.$$

thus produced is, however, mixed with vapour of bromine and sul-
oduced in the manner represented by the equation:

$$r + 2H^2SO^4 = 2Br + SO^2 + 2H^2O + Na^2SO^4;$$

eparated by agitation with mercury; but the sulphurous anhy-
noved.—3. The aqueous solution of the acid may be prepared by
n of bromide of barium with sulphuric acid diluted with an equal
distilling the filtered liquid.—4. Also by passing sulphuretted
ure of bromine and water:

$$Br + 2H^2S + 4H^2O = 10HBr + H^2SO^4 + S$$

to separate the precipitated sulphur, and the hydrobromic acid
lphuric acid by distillation.—5. By the action of bromine on
queous ammonia, and on many organic compounds, naphthalin,

less gas having a very pungent odour, which excites coughing,
ste. Reddens litmus strongly, and excites itching and inflam-
to the skin. Fumes in the air more strongly than hydrochloric
y, by experiment, 2·71 (Löwig); by calculation $\frac{80 + 1}{2} = 40·5$,
ogen, or 40·5 × 0·0693 = 2·801 compared with air. Liquefies
C.), and solidifies at −100° F. (−73° C.) (Faraday). It is
absorbed by water, forming a strongly acid solution, which, when
ity of 1·29, and fumes strongly in the air. This saturated solu-
ature below 100° C., giving off the gas, and is thereby rendered
e acid boils at a temperature above 100°, and a very dilute acid
boiling.
. The gas is not decomposed by heat alone.—2. *Potassium* intro-
ordinary temperatures, decomposes it completely, forming bro-
nd leaving a volume of pure hydrogen equal to half that of the
oduces the same effect when aided by a gentle heat. This reac-
omposition of the acid; for the weight of 1 vol. of the gas (the
ity) diminished by the weight of half a volume of hydrogen,
h is very nearly half the observed specific gravity of bromine
itscherlich):

$$2·71 - \frac{0·0693}{2} = 2·68 = \frac{5·36}{2}$$

posed of equal volumes of bromine and hydrogen, united without
he gas, or its aqueous solution, is immediately decomposed by
acid being formed and bromine separated, recognisable by its
on the contrary, does not decompose hydrobromic acid. Hence
e for hydrogen is, under similar circumstances, less than that of
than that of iodine.—4. The acid is also decomposed by *oxygen*
ed bodies. The aqueous solution turns brown on exposure to the
f bromine, which remains dissolved. *Nitric acid* also separates

the bromine, especially on heating the liquid. The mixture of the
gold, like nitrohydrochloric acid. Strong *sulphuric acid* decompo
phurous anhydride, bromine, and water:

$$H^2SO^4 + 2HBr = SO^2 + 2H^2O + Br^2.$$

With *bromic acid*, it yields water and free bromine:

$$HBrO^3 + 5HBr = 3H^2O + Br^6.$$

5. With metallic *protoxides*, it forms water and a bromide
$2HBr + Ag^2O = 2AgBr + H^2O$. With *peroxides*, a similar decom
attended also with evolution of bromine: *e.g.* 2HBr + MnO = M

Combinations. — Hydrobromic acid unites directly with *amm*
hydrobromate of ammonia, $NH^3.HBr$, or bromide of ammonium,
with the compound ammonias, *methylamine*, *ethylamine*, &c., and
hydrogen. The aqueous solution dissolves certain *metallic oxides*,
earths, forming solutions, which may be supposed to contain h
those oxides. It unites with many *hydrocarbons*, *e.g.* with oil of
the compound $C^{10}H^{16}.HBr$.

Bromides, Metallic. MBr. — Bromine unites directly with
tassium, arsenic, antimony, and tin unite with liquid bromine, p
bustion; bismuth, iron, and mercury combine with it at ord
without combustion; but on the application of heat, combustion
combines gradually with bromine at ordinary temperatures; platin
many metals, the application of heat is necessary to induce combus
also formed by the action of metals on hydrobromic acid gas (
bromine passed over ignited potash, soda, baryta, or lime, form
metal and eliminates the oxygen; bromine decomposes oxide of
nary temperatures. Carbonates are also readily decomposed by it

Nearly all bromides are soluble in water; bromide of lead however
ingly, and bromide of silver and mercurous bromide are quite inso
bromides may all be produced by the action of hydrobromic acid o
oxides or carbonates; and on evaporating the solutions, water is
off, the metallic bromide remaining. Some of them, however, v
magnesium, aluminium, and the other earth-metals, are more
during the evaporation of the solutions, giving off hydrobromic
mixture of bromide and oxide of the metal.

Metallic bromides are solid at ordinary temperatures; most
moderate heat, and volatilise at higher temperatures. They str
chlorides. The bromides of gold and platinum are decomposed b
heat; many others give up their bromine when heated in contact
rine, with the aid of heat, drives out the bromine and converts t
Hydrochloric acid also decomposes them at a red heat, giving of
Strong sulphuric or nitric acid decomposes them, with evolution o
which, if the sulphuric or nitric acid is concentrated and in exce
posed, with separation of bromine and formation of sulphurous
oxide (p. 672). Bromides heated with sulphuric acid and peroxi
chromate of potassium, give off free bromine. If the bromide
evolved bromine is completely decolorised by ammonia; but if chl
cholorochromic acid distils over, together with the bromine, and
forms a yellow liquid with ammonia.

Bromides in solution are easily decomposed by chlorine, eithe
or dissolved in water, the liquid acquiring a red or reddish-yellow
the quantity of bromine present; and on agitating the liquid wit
dissolves the bromine, forming a red solution, which rises to the
MINE.

Soluble bromides give with *nitrate of silver*, a white precipitate
greatly resembling the chloride, but much less soluble in ammon
nitric acid. *Mercurous nitrate* produces a yellowish-white precip
lead, a white precipitate much less soluble in water than the chlor
ladium produces in solutions of bromides not containing chlorine
of bromide. Chloride of palladium produces no precipitate; neit
if soluble chlorides are present.

Bromides of Organic Radicles. Bromine unites with organ
and acid. The compounds are formed in the same manner a
chlorides, which they also resemble in most of their properti
less volatile. They contain, in two volumes of vapour, one, two,

ling as the organic radicle which they contain is mono-, di-, or

nide of tritvl	C^3H^7Br	contain	1 vol.	bromine
,	tritylene $(C^3H^6)''Br^2$	„	2 vol.	„
,	glyceryl $(C^3H^5)'''Br^3$	„	3 vol.	„

the alcohol-radicles, hydrobromic or bromhydric ethers, are
he corresponding alcohols with hydrobromic acid or bromide of

$$\underset{\text{hol.}}{H.O} + PBr^5 = \underset{\text{Bromide of ethyl.}}{C^2H^5Br} + HBr + \underset{\text{Oxybromide of phosphorus.}}{PBr^3O}$$

they yield the corresponding alcohol and a bromide of the

cid-radicles are produced by the action of bromide of phosphorus
acids, or by the action of chlorides of acid-radicles on certain
bromide of acetyl, $C^2H^3O.Br$; *bromide of succinyl*, $(C^4H^4O^2)''Br^2$.
n, with formation of a metallic bromide, and a salt of the cor-
l, *e.g.*:

$$\underset{\text{omide of ccinyl.}}{H^4O^2)''Br^2} + 2KHO = \underset{\text{Succinate of potassium.}}{C^4H^4O^2.K^2.O^2} + KBr.$$

aldehyde-radicles are monatomic bromides of the general form,
ide of vinyl, C^2H^3Br. They are isomeric with the monobromi-
-radicles, *e.g.* C^3H^5Br, with bromotritylene, $C^3\frac{H^5}{Br}$. They are
d by the action of alcoholic potash on the bromides of the
s: their properties and reactions are analogous to those of the
(*q. v.*)

ic radicles, such as oil of turpentine, its isomers and homo-
ith bromine and with hydrobromic acid, forming definite com-
id, sometimes crystalline, *e.g. bromide of cajputene*, $C^{10}H^{16}Br^4$;
tine-oil, $C^{10}H^{16}.HBr$, &c.

E. See the next article.

E. The name of a doubtful compound, which Erdmann ob-
romisatin and dibromisatin, by the action of bromine on indigo.
sh into bromindoptic (bromophenissic) acid, and a volatile
nn bromindamite, but doubtless identical with tribromo-
. d. Chem. 1te Aufl. iv. 22.)

bol Br. *Atomic weight* 80.—This element was discovered in
xtracted it from the mother-liquor of the salt-marshes of Mont-
a-water; in the water of many salt-springs, especially in that
Kreuznach in Prussia, whence a large portion of the bromine of
and, together with iodine, in the ash of sea-weed (*soude de*
quantities are extracted; also in sponges and many marine
of silver, it is found native in Mexico and Chili, and at Huel-
y small quantities are found in Silesian zinc-ore and in English

m the mother-liquor of sea-water or saline-springs. After these
l by crystallisation from the greater part of the chlorides and
l potassium, the remaining liquid contains bromine, chiefly in
magnesium. This liquid is mixed in a retort with peroxide of
loric acid, and distilled. Chlorine is then evolved in the liquid,
omide of magnesium, setting free the bromine, which distils
in the form of a heavy dark-red liquid, surmounted by an
mine.—2. *From the mother-liquor of varec.* This liquid con-
ne, in the proportion of about 1 pt. bromine to 8 iodine. The
ed either by passing chlorine gas into the liquid, till a sample
ipitate either with chlorine-water or with iodide of potassium;
ree iodine and cuprous iodide, by adding cupric sulphate to the
$I = 2Na^2SO^4 + Cu^2I^2 + I^2$). The remaining liquid is then mixed
nese and strong sulphuric acid (the requisite proportions being

first determined by trial on a small quantity) and distilled. The b
over as before, the decomposition being effected in the manner show

$$Mg''Br^2 + MnO^2 + 2H^2SO^4 = Br^2 + Mg''SO^4 + Mn''S$$

The bromine which collects at the bottom of the receiver in either m
is separated from the supersaturated aqueous solution by means of
further purified by distillation in contact with chloride of calci
solution is shaken up with ether; the red ethereal solution of bron
the top is treated with caustic potash, till its colour disappears, wh
bromate of potassium are produced; the liquid is evaporated to
residue is ignited in a crucible, to convert the bromate $KBrO^3$, i
The whole quantity thus obtained is decomposed by distillation wit
ganese and sulphuric acid, whereby the remaining quantity of bro
the free state.

Commercial bromine is generally contaminated with chlorine,
that which is used to separate it, or from the mother-liquor itself.
by saturating it with hydrate of barium, whereby bromide, chlo
hypochlorite of barium are formed; evaporating and igniting to dec
salts; and treating the residue with alcohol, which dissolves the
and leaves the chloride. The pure bromide is then decomposed
and peroxide of manganese, as above.

Properties.—Bromine is, at ordinary temperatures, a liquid of a de
It has a peculiar irritating, disagreeable odour; whence its name
pulsive taste. It is highly poisonous; a drop placed on the beak o
to destroy life. Specific gravity 2·966 (Balard); between 2·98
(Löwig); 3·1872 at 0° C. (Pierre). It is a non-conductor of elec
it solidifies, forming a hard, brittle, laminated mass, having a da
and semi-metallic lustre: it retains the solid state for a long tim
It is very volatile; a few drops thrown into a large flask spee
vapours. It boils at 63° C. (Pierre); at 58° (Andrews); at 45°
density 5·54 (Mitscherlich); by calculation, 80 compared wit
($= 80 \times 0{\cdot}0693$), compared with air.

Bromine dissolves sparingly in water, more readily in alcohol, ar
in ether. With water at 0° C. it forms a solid hydrate, $Br.5H^2O$,
posed between 15° and 20°.

Bromine resembles chlorine in many of its properties. It has a
hydrogen, though not quite so strong as that of chlorine, and hence
upon many organic substances. It is a powerful bleaching agent,
and cork, first turning them yellow. A small quantity of it imp
low colour to the skin; a larger quantity stains it permanently
and a still larger quantity produces immediate corrosion and viole
colours starch orange-yellow. It decomposes vapour of water
through a tube heated to bright redness, yielding hydrobromic a
burning taper introduced into vapour of bromine, burns for an i
light, and is then extinguished.

Bromine decomposes phosphoretted hydrogen, sulphydric acid,
metallic iodides, but the resulting bromine-compounds are decom

Bromine acts readily on many organic compounds, removing p
in the form of hydrobromic acid, while another portion of bromin
the hydrogen thus abstracted, 80 pts. bromine being always i
1 pt. of hydrogen removed. In this manner, bromacetic acid, C
siderable number of other brominated compounds, are formed.

Bromine unites with all the elementary bodies, and with many
In all its compounds, except those with chlorine, fluorine, oxyg
phur, it plays the part of the chlorous or electro-negative eleme
it is intermediate between chlorine and iodine, expelling the latt
tions with positive radicles, and being itself expelled by the for
p. 672). We shall here describe only those compounds in wh
electro-positive, viz. the chlorine, fluorine, oxygen, and sulphur-con
are described under the several positive radicles.

BROMINE, CHLORIDE OF. Bromine absorbs a large
gas, forming a reddish-yellow, mobile liquid, very volatile, and gi
strong-smelling, and tear-exciting vapours, which exert a powerf
and in which metals burn quickly to chloride and bromide.

When chloride of bromine is mixed with a small quantity of
0° C., or when gaseous chloride of bromine is passed through a g

, the hydrated chloride of bromine is formed, which crystallises in
laminæ, and melts at 7° C. to a light yellow liquid. It is decomposed by
forming nitrogen gas, chloride of nitrogen, and bromide of ammonium.
f bromine dissolves with yellow colour in water. The same solution is ob-
lissolving bromine in saturated chlorine-water; it has the odour and bleach-
of chloride of bromine; decomposes in sunshine into hydrochloric and
ds, and is decomposed in like manner by aqueous alkalis, yielding a chloride
mate of the alkali-metal. The aqueous solution is decomposed by ether,
rates and dissolves the bromine. (Handw. d. Chem. ii. [2] 475.)

INE, DETECTION AND ESTIMATION OF. 1. *Reactions.*—
ine is recognised by its odour, the deep-red colour of its vapour, and the
low colour which it imparts to gelatinous starch. When it exists in aqueous
too small quantity to be recognised immediately, it may be separated by
the liquid with ether, and proceeding as described below.
in the state of hydrobromic acid or a soluble metallic bromide, is detected
ctions already described (pp. 672, 673). Small quantities of bromine are most
gnised by cautiously adding chlorine-water till the solution assumes a red
int; if too much chlorine be added, chloride of bromine will be formed,
colourless. On shaking the solution with ether, that liquid dissolves the
nd rises to the surface in the form of a red stratum. This may be separated
tte, or tap-funnel; neutralised with potash, which decolorises it, converting
ne into bromide and bromate of potassium; and evaporated to dryness in
crucible. On igniting the residue, to convert it all into bromide, then intro-
nto a test-tube, and heating with sulphuric acid and peroxide of manganese,
given off in red vapours, which, if led into a solution of starch, colour ı
low.
esence of chlorides does not interfere with this reaction; if, however, the
f chlorine is very large compared with that of the bromine, as in saline
is best to concentrate the solution till the greater part of the chlorides crys-
and search for bromine in the mother-liquor. If iodine is present, it must
noved, either by precipitation with chloride of palladium, or by first adding
ient chlorine-water to precipitate the iodine, which is sure to be set free
bromine: in fact, bromine itself separates iodine from its compounds;
emoval of the iodine is absolutely necessary, as its deep violet vapour
guise the colour of the bromine, unless the quantity of the latter greatly
ted.
thods of decomposing insoluble bromides will be given further on; likewise
ds of separating bromine from phosphorus, and other non-metallic elements.
are reduced to bromides, either by ignition or by treatment with sulphurous
lric acid.

ntitative Estimation.—When bromine is present in a solution in the
bromide, it may be precipitated by nitrate of silver, the precipitate of
f silver being ignited in a porcelain crucible, with the same precautions as
le (see CHLORINE). It contains 42·55 per cent. bromine. If the solution is
t must be acidulated with nitric acid, added after the precipitation by
silver; if it were added before, a portion of the bromine might be set free

e bromides, *e.g. bromide of lead*, and *cuprous bromide*, may be decomposed
ling them in water, and passing sulphuretted hydrogen through the liquid.
is then converted into sulphide, while hydrobromic acid remains dissolved
ith excess of sulphydric acid. This excess may be removed by addition of
hate, which precipitates sulphur, and in the filtered liquid the bromine may
ed, as above, by precipitation with nitrate of silver. *Bromide of silver* may
composed by fusion with carbonate of sodium, or, better, with a mixture of
of sodium and carbonate of potassium in equivalent proportion, in a porcelain
The silver is thereby reduced to the metallic state, and may be weighed
ing. The bromine is then estimated by loss.
method of decomposing bromide of silver, is to treat it with dilute sul-
l and pure metallic zinc. The silver is then reduced by the nascent hydrogen,
romine passes into the solution as bromide of zinc. The silver may then be
nd weighed as before. This method, however, is not quite exact (see
).—*Mercurous bromide* may be completely decomposed by a solution of pure
tash, a solution of bromide of potassium being formed, from which the
ay be precipitated by nitrate of silver with addition of nitric acid.
rybromides which are insoluble in water, are soluble in nitric acid. The
d be dilute, and if heat is required, the materials must be placed in a flask

having a glass stopper, and the heat kept as low as possible, othe
escape. The bromine may then be thrown down as bromide of silv

Volatile bromides, such as the bromides of sulphur, phosphoru
mony, are completely decomposed by water, the bromine being co
bromic acid, from which it may be precipitated by nitrate of silver

Bromates must be reduced to bromides by sulphurous or su
bromine may then be precipitated by silver-solution, after the exc
agent has been removed by a ferric salt. Bromates may also be conv
by ignition.

The quantity of *free bromine* in a solution, is estimated by treati
ammonia, whereby it is completely converted into bromide of am
lution of nitrogen. The diluted solution is then treated with nitra

Estimation of Bromine in presence of Chlorine.—There is no
effecting a complete separation of these elements, and when they c
amounts must be estimated by an indirect method. This is effect
them both together by nitrate of silver; fusing and weighing th
in a porcelain crucible; then remelting it; taking out a conveni
end of a glass rod; cutting it when cold into small shavings; i
to a bulb-tube; and igniting them, after weighing, in a current of
whole of the bromine is then expelled, provided the stream of c
for some time, and nothing but chloride of silver remains. This is
its weight, and that of the mixture of chloride and bromide before
quantities of chlorine and bromine may be found. For the differe
(d) is clearly the difference between the weight of the bromine e
the chlorine which has taken its place; and for every 80 pts. o
35·5 pts. of chlorine have come in: hence we have the equations:

$$\mathrm{Br} - \mathrm{Cl} = d: \qquad \frac{\mathrm{Br}}{\mathrm{Cl}} = \frac{80}{35{\cdot}5}$$

$$\text{whence:} \qquad \mathrm{Br} = \frac{80}{80 - 35{\cdot}5}\,d = 1{\cdot}796\,d$$

that is to say: to find the quantity of bromine, *multiply the diffe*
by 1·796.

If the quantity of bromine is very small compared with the ch
does not give exact results. In that case, it is necessary to *conc*
that is, to increase the proportion of it in the precipitate subjected
Now when a mixture containing a large quantity of soluble chloric
portion of bromide, is treated with about one-sixth of the quantity
required for complete precipitation, the whole of the bromine is pr
with a portion of the chlorine. The liquid must be briskly ag
precipitate to settle down, but no heat must be applied. The pre
be ignited, weighed, and decomposed in a stream of chlorine in th
scribed. The remainder of the chlorine, now free from bromine
chloride of silver in the usual way. Another method of concentrat
a mixture of chloride of sodium containing a small quantity of l
the dry mixture with very strong alcohol, which dissolves the whol
sodium, but only a small portion of the chloride. The filtered a
then evaporated, the residue is dissolved in water, and the bromi
precipitated by nitrate of silver and estimated as before. To esti
of bromine in sea-water or a brine-spring, the liquid must be evapo
weighed quantity of carbonate of sodium having been previously a
loss of bromine and chlorine which might arise from the decompos
and bromide of magnesium during the evaporation, and the dry r
alcohol as above.

Estimation of Bromine in presence of Iodine.—The iodine is prec
of palladium (or by the nitrate, if chlorides are present, p. 674),
ladium removed by sulphuretted hydrogen, the excess of this la
acid or a ferric salt, and the bromine then precipitated by nitrate

(For other modes of estimation, see CHLORINE and IODINE.)

Field (Chem. Soc. Qu. J. x. 234) has shown that chloride of s
decomposed by digestion with solution of bromide of potassium
bromine changing places; and that both bromide and chloride of sil
in like manner by iodide of potassium. Hence, if a solution c
iodine, and bromine, be divided into three equal parts; each port
nitrate of silver; the first precipitate dried and weighed; the se
bromide of potassium, then dried and weighed; and the third w

and weighed, the relative quantities of the three elements may be
extension of the method of calculation above given (see also p. 224).
of the three precipitates be w, w', and w''; also let the atomic weights
ide, and iodide of silver be c, b, and i respectively, and the unknown
oride, bromide, and iodide of silver, x, y, and z; then we have the

$$x + y + z = w$$

$$\frac{b}{c}x + y + z = w'$$

$$\frac{i}{c}x + \frac{i}{b}y + z = w''$$

econd give: $x = \dfrac{c(w - w')}{b - c}$

is value in the second and third, they become:

$$y + z = w' - \frac{b(w - w')}{b - c} \quad [= p]$$

$$\frac{i}{b}y + z = w'' - \frac{i(w - w')}{b - c} \quad [= q]$$

whence: $y = \dfrac{b(q - p)}{i - b}$

and: $z = w - (x + y)$.

etric estimation of bromine, see Analysis, Volumetric (p. 267). For
bromine in organic compounds, see Analysis, Organic (p. 247).

eight of Bromine.—The older determinations of the atomic weight
much too low. Balard estimated it at 75·8, Liebig at 75·2, Berzelius
ost exact determinations are due to Marignac (Biblioth. univ. de
7), who found: 1. That 100 pts. pure silver dissolved in nitric acid
by bromide of potassium, yielded, as a mean, 174·065 pts. bromide of
he atomic weight of silver being 108, that of bromine is $x = 74{\cdot}065 \times$

2. That 100 pts. silver required for precipitation, 110·36 pts. bromide

whence if Ag = 108 and K = 39·1, we have 100 : 110·36 = 108 :
nce $x = 80{\cdot}09$.—3. That 100 pts. bromate of potassium give off by
average, 29·723 pts. oxygen, whence Br = 79·97. The mean of all
very nearly Br = 80, which is the number now universally adopted.
at the same result by igniting bromide of silver in chlorine gas, and
difference of weight thereby produced.

, **FLUORIDE OF.** Fluorine is readily absorbed by bromine. The
und, according to Leesen (Phil. Mag. Dec. 1844, p. 520) is liquid,
water, and does not sensibly attack glass. It has been used as a
ating the taking of photographic pictures by the electric light. (Compt.
.)

, **OXYGEN-ACIDS OF.** The series of oxygen-compounds of bro-
eans so complete as that of chlorine. No anhydrous oxide of bromine
of the acids, only one has been obtained in the separate state and
nined, viz. Bromic acid, $HBrO^3$, already described (p. 669). All
are a perbromic acid, analogous to perchloric acid, $HClO^4$, have been
at the existence of hypobromous acid, HBrO, is rendered probable
ments, though neither the acid itself, nor any of its salts, have yet
definite form.

ic oxide is added to bromine-water, a sparingly soluble oxybromide of
ed, together with a bleaching liquid, which, by distillation in vacuo,
upposed to be *hypobromous acid* (Balard). According to Gay-Lussac,
hydride may be obtained in the gaseous state in the same manner as
hydride. (See Chlorine, Oxides of.)

e is added to cold dilute aqueous alkalis, a metallic bromide is formed,
very small quantity of bromate, and a liquid, which does not smell of
es litmus and indigo and vegetable colours in general, and gives off
act with ammonia. On heating the liquid, no bromine is evolved, but
med and the bleaching power is destroyed. These phenomena are
ous to those which are exhibited when chlorine is dissolved in cold
s. (See Hypobromous Acid.)

BROMINE, SELENIDE OF. See SELENIUM, BROMIDE OF.

BROMINE, SULPHIDE OF When bromine is brought flowers of sulphur at ordinary temperatures, a dark brown, fuming, oily having an odour like that of sulphide of chlorine. It is not altere but water at 10° C. decomposes it with slight explosion, forming bromic, and sulphydric acids. When it is distilled, the first third appears to consist of Br^2S^2, while the liquid remaining in the retort this compound with another sulphide of bromine, and, even when t completed, there still remains a viscid liquid containing bromine. Ann. xxviii. 550.)

BROMIODOFORM. $CHBr^2I$.—This compound is produced form with bromine. It is a colourless liquid, which solidifies to a c at 0° C.; melts at + 6°; is very volatile; has a penetrating odour and It may be regarded as *dibrominated iodide of methyl.* (Sérullas [2] xxxiv. 225; xxxix. 97.—Bouchardat, J. Pharm. xxiii. 10.)

BROMISATIC ACID. See ISATIC ACID.

BROMISATIN. See ISATIN.

BROMITE. Native bromide of silver, found in Mexico and in C BROMIDE OF.)

BROMITONIC ACID. See CITRACONIC ACID, DECOMPOSITIO

BROMLITE. Syn. with ALSTONITE.

BROMO-COMPOUNDS or **BROMINATED COMPOUN** resulting from the substitution of bromine for hydrogen, chiefly in They are produced by the action of bromine or of bromide of phosph acids, hydrocarbons, &c. Most of them are described under the compounds, *e.g.* BROMOBRUCINE under BRUCINE, &c.

BROMOFORM. $CHBr^3$.—Produced by the simultaneous a and caustic potash on wood-spirit, alcohol, or acetone; also by the a on aqueous citric or malic acid; and by decomposing bromal with limpid liquid of specific gravity 2·13, having an agreeable odour and It is less volatile than chloroform, very little soluble in water, to w imparts its taste and odour; soluble in alcohol, ether, and essential small quantities of sulphur and phosphorus, and a large quantity of i with difficulty. When its vapour is passed through a red-hot tube, i charcoal and bromine-vapour. Boiling potash-ley decomposes it chloroform, yielding formate and bromide of potassium. (Löwig, iii. 295.—Dumas, Ann. Ch. Phys. [2] lvi. 120.)

BROMOPICRIN. CBr^3NO^2.—A product obtained by distillin hypobromite of calcium (p. 923).

BROMOSAMIDE. See SALICYLAMIDE.

BROMOTRICONIC ACID. } See CITRIC AND CITRACONIC
BROMOXAFORM. } sitions by bromine.

BROMUS. A genus of grasses. The ashes of *Bromus erectus* a have been analysed by Way and Ogston (Journal of the Royal 530). 100 pts. of *Br. erectus* (air-dried) yielded 59·6 per cent. water *Br. mollis*, 76·6 per cent. water and 1·4 ash.

100 pts. of ash were found to contain:

	K^2O	Na^2O	$Ca''O$	$Mg''O$	Fe^2O^3	SO^3	SiO^2	CO^2	P^2
Br. erectus . .	20·3	—	10·4	5·0	0·26	5·5	38·5	0·5	7·
Br. mollis . .	30·1	0·3	6·6	2·6	0·21	4·9	33·3	9·1	9·

BROMYRITE. Native bromide of silver. See SILVER.

BRONZE. An alloy of copper and tin. See COPPER.

BRONZITE. *Schillerspar. Diallage fibro-laminaire.*—A miner the augite family (p. 476). It is massive, with laminar structure inc Colour varying from yellowish-brown to pinchbeck-brown. Lustre pearl to bright adamantine (pseudo-metallic). Harder than felspar. 3·201 to 3·25. Like all the augites, it is a metasilicate, its genera $M''SiO^3$ or $M''O.SiO^2$, the $M''O$ denoting lime, magnesia, manganous o oxide in variable proportions, the magnesia, however, predominating. large masses in beds of serpentine.

Delesse examined a mineral from the serpentine of Houx in th resembled bronzite in its large amount of magnesia (56·33 Si^2O; Cr^2O^3; 6·73 $Fe''O$; 31·93 $Mg''O$; 1·40 $Ca''O$; 2·11 loss by ignition);

he same metallic lustre and pinchbeck-brown colour, and in being
able, especially parallel to oP; specific gravity 3·154 (Ann. Min.
'or other analyses of bronzite, see Gm. Handb. iii. 403, 404;
J. [2] xv. 333; Kjerulf, Bischof's Lehrb. d. chem. u. phys.

Jurinite. Arkansite.—One of the forms of native titanic anhydride
rphous. The crystals belong to the trimetric system, and generally
ated combinations, among which we may assume, as the primary
, in which the lengths of the brachydiagonal, macrodiagonal, and
one another, as 0·5951 : 1 : 0·5558. Angle of the terminal edges
al section = 135° 46′; in the macrodiagonal section = 101° 37′;
lges = 94° 44. The crystals exhibit, together with P, the faces
ikewise other pyramids and horizontal prisms; and are often
ar form by predominance of the faces ∞ P̆ ∞. Cleavage parallel
red, brown, or black, with adamantine or semi-metallic lustre.
ue. Streak yellowish-white. Hardness = 5·5 to 6·0. Specific
·22. Brittle. It is found at Oisans in Dauphiné, at Tremadoc in
othard, in the Valorsina and the Griesernthal in Switzerland, at
and at Magnet Cove in Arkansas. The crystals from the last-
vere at first regarded as a distinct species, called *Arkansite.* (Kopp,
[2] 521; Krystallographie, p. 256.)

variety of bitterspar from the Brossa valley in Piedmont and
inguished by a rather large amount of iron. A specimen from
d by Hirzel (Zeitsch. f. Pharm. 1850, p. 24), yielded 11·13 per
te.

IA TINCTORIA or *Morus tinctoria.* — The plant which
od. (See Morus and Morintannic Acid.)

RIES. — The fruit of *Rubus fructicosus.* See Rubus.

animarine. Vomicine.—$C^{23}H^{26}N^2O^4 + 4H^2O$ (Pelletier and Ca-
n. Ch. Phys. [2] xii. 118; xxvi. 53.—Pelletier and Dumas,
orriol, J. Pharm. xi. 495.—Liebig, Ann. Ch. Phys. [2] xlvii.
rm. xxxi. 50.—Regnault, Ann. Ch. Phys. [2] lxviii. 113). This
xists, together with strychnine, in nux vomica (the seed of *Strych-*
the bean of St. Ignatius (the seed of *Strychnos Ignatii*), in the
Colubrina, and in *upas tieute*, an extract prepared from the bark of
, and used by some of the natives of the East Indian Archipelago,
arrows. It also exists in large quantity, and unaccompanied by
angustura bark, originally supposed to be the bark of *Brucia an-*
w ascertained to belong to a species of strychnos, probably *Strych-*

From false angustura bark.—The pulverised bark is treated with
ty matter, then digested in strong alcohol; the dry alcoholic ex-
water; the colouring matter precipitated by subacetate of lead; the
ved by sulphuretted hydrogen; and the liquid, which contains the
, is boiled with magnesia, again filtered and evaporated. The
ained in the form of a granular mass, generally coloured. To
it is saturated with oxalic acid; the oxalate of brucine is washed
ol cooled to 0° C. which dissolves the colouring matter, then
, and decomposed by lime or magnesia; and the brucine thus set
in alcohol and crystallised by slow evaporation (Pelletier and
nard (Traité de Chimie, 6th ed. iv. 281), recommends as an
preparing brucine, to treat the bark with boiling water, add oxalic
decoction, concentrate by evaporation, and purify the oxalate of
cohol, as above.

of Strychnos nux vomica, &c. — The mother-liquors obtained in
strychnine from these seeds (see Strychnine), contain brucine,
ined from them by concentrating to the consistence of syrup, and
ting with dilute sulphuric acid. The mixture, if left to itself for
s crystals of sulphate of brucine, which are to be pressed, redis-
vater, and decolorised by animal charcoal. The brucine is then
nia.

ine crystallises by slow evaporation from its solution in hydrated
homboïdal prisms, often rather large, and sometimes agglomerated
hrooms. By rapid crystallisation from boiling water, nacreous
e obtained, having the aspect of boric acid. The crystals contain
allisation (= 15·45 per cent.); they effloresce quickly in dry air,

and melt in their water of crystallisation at a little above 100° C.
850 pts. of cold, and 500 pts. of boiling water; they are very solub
ingly in essential oils, insoluble in ether and in fat oils. The alco
the plane of polarisation to the left; specific rotatory power =
diminish the rotatory power.

Brucine is poisonous, and acts on the animal economy like st
much less energy.

Decompositions.—1. Strong *nitric acid* colours brucine deep red,
nitro-compound (cacotheline), and evolving nitrite of methyl, to
oxide and carbonic anhydride, this last not being a direct product
resulting from the decomposition of oxalic acid previously formed.
Ch. Pharm. xci. 76.)

$$C^{23}H^{26}N^2O^4 + 5HNO^3 = \underset{\text{Cacotheline.}}{C^{20}H^{22}N^4O^9} + \underset{\text{Nitrite of methyl.}}{CH^3.NO^2} + \underset{\text{Oxal acid}}{C^2H^2O^4} +$$

The addition of protochloride of tin to the mixture changes the
violet. This, together with the red colour first produced, is qu
brucine, and serves to distinguish it from other alkaloids.—2. Str
imparts to brucine, first a rose, then a yellow, and then a yellow
3. Brucine boiled with peroxide of lead and excess of sulphuric aci
red mass. This character further distinguishes brucine from stryc
treated with sulphuric acid and peroxide of lead, assumes a blu
through violet and red to yellow.—4. Brucine distilled with *sulph*
oxide of manganese, gives off inflammable vapours and a liquid (
methyl), which burns with a blue flame; the same liquid is pro
brucine with mercuric oxide, or with sulphuric acid and chromate
bonic and formic acids being likewise evolved in the latter case.
not produce immediate turbidity in a solution of brucine, but co
afterwards red; this last colour disappears after a while, the liqui
depositing yellow uncrystallisable flakes.—6. *Bromine* dissolved
attacks brucine, colouring it violet. With a weak solution of brom
brucine, a resinous matter is formed, together with *bromobrucine.*
with brucine two peculiar compounds. Iodide of ethyl converts
of ethylbrucine.

Combinations.—The SALTS OF BRUCINE have a bitter taste, and a
crystallisable. Strong nitric acid colours them red. They are de
by mineral alkalis, but also by morphine and strychnine, wh
brucine. When diluted with water and mixed with a slight exce
they are not precipitated by acid carbonates of alkali-metals.

ACETATE OF BRUCINE is very soluble and uncrystallisable.

CHLORATE OF BRUCINE.—Transparent rhombs. Decomposes sudd
heated.

HYDROCHLORATE OF BRUCINE, $C^{23}H^{26}N^2O^4.HCl$, or *Chloride of Bruc*
(at 140° C.) A solution of brucine in dilute hydrochloric acid, yield
in crystalline tufts, moderately soluble in water. The *chloromercura*
$Hg''Cl^2$, is obtained as a crystalline magma on mixing the alcoholic
component salts; and if the mass be heated with a small quantity of
hydrochloric acid, the liquid on cooling deposits the double salt in
must be washed, first with a large quantity of water, and then with

The *chloroplatinate*, $2(C^{23}H^{26}N^2O^4.HCl).PtCl^4$, is obtained as a p
yellow colour, by mixing a solution of sulphate of brucine with tetrac

HYDROFERROCYANATES OF BRUCINE.—Three of these salts are know
$4HCy.Fe''Cy^2 + 2H^2O$. Precipitated on mixing a solution of ferrocy
with nitrate of brucine, in shining needles, sparingly soluble in cold,
water and alcohol; very hygroscopic. When heated to 100° C. or
it decomposes, giving off hydrocyanic acid, and depositing a blue p
alcoholic solutions of brucine and hydroferrocyanic acid form a whi
cipitate soluble in excess of brucine. It is nearly insoluble in wa
has an acid reaction, and is rapidly decomposed by heat. γ. A cold
forms with ferricyanide (red prussiate) of potassium, a deep yello
pitate, which appears to be more stable than the salt, &c. (B
Pharm. lxvi. 266.)

HYDROFLUATE OF BRUCINE.—A solution of brucine in warm,
trated hydrofluoric acid, deposits, on cooling, small colourless prisms,
in water, sparingly in boiling alcohol, nearly insoluble in cold alco
per cent. water at 100° C.

of Brucine. $C^{23}H^{26}N^2O^4.HI$ + aq.—Rectangular laminæ, or very short
gly soluble in cold, more soluble in hot water; dissolves in alcohol more
water. (Regnault.)

Brucine.—A solution of brucine in iodic acid, not in excess, yields by
o salts, viz. an acid salt, which crystallises in hard, transparent, four-
nd an opaque silky salt, which appears to contain an excess of base.

Brucine. α. $(C^{23}H^{26}N^2O^4)^2.I^3$.—Orange-yellow precipitate, obtained by
l alcoholic solution of brucine, a quantity of tincture of iodine not suffi-
e compound β. (Analysis 33·3 per cent. iodine; calc. 32·4 per cent.)
$^4.I^3$.—Produced by triturating brucine with excess of iodine, either in
coholic tincture. Brown powder soluble in hot alcohol. Treated with
id, it gives off iodine and yields a salt of brucine. With nitrate of
a precipitate of iodide of silver. Gave by analysis 36·13 per cent. C;
·66 I; calc. 35·8 C, 3·4 H, and 48·9 I. (Pelletier, Ann. Ch. Phys.

Brucine. $C^{23}H^{26}N^2O^4.HNO^3$ + 2aq.—A solution of brucine in dilute
lds this salt in colourless four-sided prisms, bevelled at the summits.
water than nitrate of strychnine.

Brucine crystallises in long needles, especially when the acid is in
gly soluble in absolute alcohol.

of Brucine.—Small prisms, sparingly soluble in cold water, more
water and in alcohol. Gives off 5·4 per cent. water at 170° C., and
igher temperature.

f Brucine crystallises from an alcoholic solution by evaporation at
beautiful colourless needles, which are decomposed by heat with a
Ioderately soluble in water and alcohol; the solutions turn brown when
air. (Bödeker, Ann. Ch. Pharm. lxxi. 64.—Langlois, Ann. Ch.
. 278.)

of Brucine. α. $(C^{23}H^{26}N^2O^4)^2.H^3PO^4$, or $(C^{23}H^{27}N^2O^4)^2.H.PO^4$. (at
ution of brucine in tribasic phosphoric acid yields the salt, when concen-
shortened prisms, having a faint yellowish colour, sparingly soluble in
dissolving in any proportion in hot water. Neutral to litmus paper. The
water, which they lose on exposure to the air. At 100° they fuse in
rystallisation to a resinous mass, from which it is difficult to expel the
ater.—β. *Acid Salt.* Obtained by using an excess of acid. Crystallises
ular plates, very soluble and efflorescent.—γ. *Phosphate of Brucine and*
$O^4.NaH^2PO^4$ (at 100° C.) Obtained by digesting brucine with ordinary
dium. Short opaque prisms. (Anderson, Phil. Mag. [3] xxxiii. 163.)

of Brucine crystallises from a boiling solution in white, silky, flexible

Brucine.—The *normal salt*, $(C^{23}H^{26}N^2O^4)^2.H^2SO^4$ + 7aq. is obtained
brucine with dilute sulphydric acid. Long needles, very soluble in
in alcohol; gives off its water at 130° C. *An acid sulphate* is ob-
allising the normal salt with sulphuric acid, and removing the excess
ing with ether.—*Double sulphates.* On adding brucine to a solution of
per or iron, part only of the metallic base is precipitated.

ate of Brucine. $C^{23}H^{26}N^2O^4.HCyS$.—Obtained by saturating an alco-
f brucine with a moderately concentrated solution of sulphocyanic acid.
s, anhydrous, soluble in water, infusible at 100° C.

of Brucine. α. *Normal tartrates.* $(C^{23}H^{26}N^2O^4)^2.C^4H^6O^6$ + 5½ aq.
—Obtained in limpid well-defined crystals by dissolving 2 at. brucine
s solution of 1 at. tartaric acid. Very soluble in hot, sparingly in cold
tartrate (dextro-rotatory) is deposited immediately in limpid laminæ,
water, 7½ at. of which are given off at 100° C., and the remainder at
22 per cent.; by calculation 13·18 per cent.) Crystallised from 95 per
ne same salt contains only 5½ at. water, or 11 at. water to 2 at. of the
are given off at 100° C., and the remainder at 150° (in all 10 per cent.;
·5 per cent.) The *antitartrate* (lævo-rotatory) always contains 14 H^2O,
lised from water or from strong alcohol. It effloresces quickly in sum-
20·66 per cent. water at 100°, and 1 per cent. more at 150° (in all 21
at.)

rates. $C^{23}H^{26}N^2O^4.C^4H^6O^6$ + 5 aq.—Obtained by mixing brucine and
n equal numbers of atoms. The *tartrate* precipitates immediately
, as a granular crystalline powder. It is always anhydrous, whether
n water or from alcohol. Begins to decompose at about 200° C. The

antitartrate contains 5 at. water (calc. 15·7 per cent.; exp. 14·5 per
13·3 per cent. (4½ at.) at 100°, the rest at 150°. Very soluble in hot,
water. Effloresces easily in dry air. (Pasteur, Ann. Ch. Phys. [3]

THIOSULPHATE, or HYPOSULPHITE OF BRUCINE $(C^{23}H^{26}N^2O^4)^2.H^2$
dried), is formed when a solution of brucine, mixed with alcohol and
monium, is exposed for some time to the air. It crystallises in pr
which dissolve in 105 pts. of cold water, and give off 1 at. water whe
of vitriol. (How, Ed. N. Phil. J. [new ser.] vol. xcviii).

Substitution-derivatives of Brucine.

BROMOBRUCINE, $C^{23}H^{25}BrN^2O^4$.—When a solution of bromine in
added to an aqueous solution of sulphate of brucine, a resinous substa
forms: and if the addition of the bromine be continued till two-third
is converted into this substance, the decanted solution then precipitat
the precipitate dissolved in very weak alcohol, and boiling water co
alcohol poured by small portions into the liquid, and afterwards a li
also boiling, a slight turbidity soon appears; and on leaving the
bromobrucine is deposited in small needles, having a slight brown colo
analysis 17·5 per cent. bromine (calc. 16·9 per cent.) It is not colour
nitric acid. (Laurent, Ann. Ch. Phys. [3] xxiv. 314.)

ETHYLBRUCINE. $C^{23}H^{25}(C^2H^5)N^2O^4$.—The *hydriodate* of this base
treating a cooled alcoholic solution of brucine with excess of iodide of
containing $2[C^{23}H^{25}(C^2H^5)N^2O^4.HI]$ + aq. insoluble in water, but re
hot alcohol. Potash does not separate the base from this salt; but
solution with recently precipitated oxide of silver, ethylbrucine [? hy
brucium, $C^{23}H^{26}(C^2H^5)N^2O^4.H.O$, analogous to hydrate of ammoniu
This base dissolves readily in water, alcohol, and ether, but cannot be
solid state. The solution has a strong alkaline reaction, precipitates fe
oxide, and alumina, redissolving the two latter in excess. It decom
salts, and absorbs carbonic acid from the air. With nitric acid, it giv
colour as brucine. It neutralises acids completely. The nitrate an
crystallise, their solutions however becoming coloured during evaporatio
chlorate forms with tetrachloride of platinum a crystalline double
$2(C^{23}H^{25}(C^2H^5)N^2O^4.HCl).PtCl^4$. (Gunning, J. pr. Chem. lxvii. 46.)

BRUCITE. *Nemalite. Lancasterite. Native Magnesia.*—MgHO,
being sometimes partly replaced by iron. Crystallises in rhombohedral
form R = 82° 15′, generally forming the combinations oR . ∞R. Clea
parallel to the base. It is usually foliated or massive; also fibrous,
separable and elastic. Hardness = 1·5. Specific gravity 2·35 (Hardi
inclining to grey, blue or green, with pearly lustre. Streak white.
various degrees, sometimes translucent on the edges only. Sectile.
laminæ. Gives off water when heated, but does not fuse. Dissolves i
efflorescence. It accompanies other magnesian minerals in serpentine
of the Shetland isles, where it is sometimes found in regular crystals;
in the Ural; at Goujat in France; at Hoboken New Jersey; and in th
York. (Dana, ii. 133.)

The name *Brucite* is also used as a synonyme of CHONDRODITE (*q. v.*)

BRUNOLIC ACID. A substance obtained by Runge from co
(Pogg. Ann. xxi. 65, 315; xxxii. 308). When the alkaline liquid obt
ing coal-tar naphtha with milk of lime, is mixed with an acid, a mixtu
carbolic acid, rosolic acid and brunolic acid separates out; and on
mixture with water, the phenic acid passes over, leaving a brown
containing rosolic and brunolic acid. When this mixture is dissolved i
tity of alcohol, and milk of lime added, a rose-coloured solution is form
rosolate of calcium, while brunolate of calcium separates as a brown pr
when decomposed by hydrochloric acid, yields brunolic acid in brown
pears to combine with bases, but neither the acid itself nor any of it
been obtained in a definite state.

BRUNSWICK-GREEN. A green pigment consisting of oxychl
$Cu^4Cl^2O^3$ = $Cu''Cl^2.3Cu''O$, prepared by moistening copper turnings wi
acid or solution of sal-ammoniac, and leaving them in contact with the
chloride then forms on the surface, and is washed off with water, and d
heat. (See COPPER.)

BRYOIDIN. One of the constituents of the resin of arbol-a-brea

BRYONIN. The bitter principle of the root of the red-berried br
dioïca). It may be obtained by treating the root with boiling water, p
filtered liquid with subacetate of lead, decomposing the precipitate wit

rating the filtered liquid, and exhausting the residue with alcohol Firnhaber, Brandes' Arch. Pharm. iii. 356). It is a yellowish-white red or brownish; tastes sweetish at first, then styptic and very bitter. and alcohol, insoluble in ether. Sulphuric acid dissolves it, forming which changes to green. It is not altered by alkalis. The aqueous uite precipitates with nitrate of silver, mercurous nitrate, and subacetate n acts as a drastic purgative, and in large doses is poisonous. (Gerh.

Walz (Chem. Centralb. 1859, p. 5), the alcoholic extract of bryony o bitter substances, bryonin and bryonitin, which may be sepa- the aqueous infusion of the alcoholic extract with subacetate of lead, es the greater part of the bryonitin, leaving bryonin in solution. eed from adhering resin by treatment with absolute ether, is a white red granular substance, transparent in thin layers, and according to $^{48}H^{80}O^{19}$; but the simpler formula, $C^8H^8O^2$, agrees well enough with e analysis. It appears to be a glucoside, and is resolved by boiling huric acid, into glucose, and two amorphous bodies, viz. bryoretin, and hydrobryoretin, insoluble in ether, but soluble in alcohol:

$$\underset{\text{Bryonin.}}{C^{48}H^{84}O^{21}} = \underset{\text{Bryoretin.}}{C^{21}H^{36}O^{7}} + \underset{\text{Hydro-bryoretin.}}{C^{21}H^{37}O^{8}} + \underset{\text{Glucose.}}{C^{6}H^{12}O^{6}}$$

ns a white crystalline mass, soluble in water and ether, insoluble in egards the bryonin of Brandes and Firnhaber as an impure substance.

N. See the last article.

(from *βοῦς*, ox). The name of a peculiar substance, said by Morin ung, and to be copiously precipitated by metallic salts, tincture of and therefore to be active in the application of cow-dung to calico-

TE. A silicate of aluminium, varying in composition between $Al^2O^3.3SiO^2$, and probably nothing but fibrous disthene mixed with STHENE and SILLIMANITE.)

DITE. See EPIDOTE.

RN. See RHAMNUS.

AT. *Polygonum fagopyrum*, and *P. tartaricum*.—A plant indigenous h cultivated in the North of Europe, where the flour is used for food. ields on the average, 43 per cent. by weight of grain, and 57 straw. ickwheat contains on the average:

	Air-dried.	Anhydrous.
enous matter	8·6	10·0
&c.	51·9	60·5
fibre, &c.	23·1	26·9
	2·2	2·5
	14·2	

pt. rend. xlvi. 203) found in 100 pts. of buckwheat-seed, 2·1 pts. sphoric anhydride, and 3·2 fat; in 100 pts. of commercial buckwheat itrogen; in 100 pts. of the coarse yellow flour: 5·6 nitrogen, 2·4 phos- e, and 7·2 fat; in the bran, 2·4 nitrogen, 1·2 phosphoric anhydride, ulder found in 100 pts. of buckwheat flour 7·5 pts. nitrogenous con- e same in the bran.

position of the Ash of the Grain and Straw of Buckwheat.

	Grain.			Straw.					
	1	2	3	4	5	6	7	8	9
	8·7	15·0	10·3	31·7	21·6	39·6	40·5	28·2	23·9
	20·1	24·0	—	—	—	—	—	—	—
	6·7	11·5	22·0	15·7	14·0	12·8	11·6	14·1	18·6
	10·4	13·5	40·3	1·6	1·9	3·2	1·4	4·7	4·2
	1·0	0·6	0·5	—	—	—	—	—	—
le	2·2	5·4	6·8	4·7	2·8	2·7	4·3	7·1	3·5
	0·7	10·6	4·4	3·6	4·1	4·1	4·2	4·8	5·2
	50·1	12·5	9·0	10·3	9·5	6·4	8·9	10·9	10·0
um	—	—	—	7·4	26·9	0·8	3·1	6·8	9·7
	—	1·0	4·9	4·5	3·0	3·2	3·7	3·4	1·7
	—	—	—	20·4	16·1	27·1	22·2	20·0	23·1
	—	1·9	0·8	—	—	—	—	—	—
	—	3·2	1·0	—	—	—	—	—	—

1. Analysed by Bichon (Ann. Ch. Pharm. l. 419). 2, 3. By Sp
Chem. vi. 402; x. 350). 4—9. By Wolff (J. pr. Chem. lii. 65).
wheat grown in unmanured soil; 5, on soil manured with chloride o
nitrate of potassium; 7, with potashes; 8, with sulphate of magnesiu

Sprengel found in the air-dried straw, 3·20 per cent. ash.

Colouring Matters of Buckwheat.—The leaves contain a yellow
first observed by Nachtigal (Jahresber. f. Chem. 1849, p. 713), fur
Schunck (Chem. Gaz. 1858, Jan. 18; Jahresber. 1857, p. 489). Acc
its composition may be most simply expressed by the formula, C^9H
bably identical with *rutin* (*q. v.*), and with Moldenhauer's *ilixanthi*
in yellow needles, dissolves sparingly in cold water, more readily
more still in alcohol. Alkalis dissolve it, forming a deep yellow sol
it is precipitated by acids; if, however, the solution be exposed to t
ing matter is transformed into an amorphous substance, easily soluble
longer precipitable by acids. Hydrochloric and sulphuric acids c
colour of the crystalline substance to deep orange: but water restore
phuric acid does not decompose it, even at boiling heat; nitric ac
oxalic acid. With oxide of lead, it forms a bright yellow compound
lead, and communicates a bright yellow colour to cotton stuffs morda
of alumina. The presence of foreign matters in the crude extract of
renders the colour somewhat impure. According to Nachtigal, 5
straw contain as much colouring matter as 1 pt. of quercitron. Acco
1000 pts. of the fresh leaves contain rather more than 1 pt. of pure c

Buckwheat straw has been said to yield indigo by fermentation; a
however, is not confirmed by the observation of Schunck (Handw.
ii. [2] 551. *Ure's Dictionary of Arts, Manufactures, and Mines*, ii.

BUCURUMANGA RESIN. A fossil resin, occurring in an a
near Bucurumanga in New Granada. It is light yellow, transparent,
than water; becomes strongly electric by friction; is insoluble in alc
ether and becomes opaque. It melts when heated, and burns in
residue. It resembles amber in outward appearance, but does not y
by dry distillation. It contains 82·7 per cent. carbon, 10·8 hydrogen
(Boussingault, Ann. Ch. Phys. [3] vi. 507.)

BUENIN. A substance obtained by Buchner from the bark of

BUHRSTONE. A cellular flinty quartz rock.

BUKKU LEAVES. The leaves of *Diosma crenata*, a rutaceo
at the Cape of Good Hope. Gassincourt (Buchn. Répert. Pharm. x
1000 pts. of them, besides gum, resin, &c., 6·6 pts. of a volatile oil, hav
colour, a sharp irritating taste and odour, lighter than water, and s
therein. Brandes (Arch. d. N. Apoth. Ver. xxii. 229) found malic
in the leaves, besides albumin, gum, resins, &c.; and in 1000 pts. 8
and 40 pts. of a yellowish-brown bitter substance, soluble in water, whi
min. Landerer (Buchner's Répert. lxxxiv. 63) found in the alco
bukku leaves, a crystalline bitter deposit, which, however, was insolu

BURATITE. A hydrated carbonate of zinc, copper, and calci
verdigris-green, radiated, acicular crystals, or plumose aggregations, c
3·32, at Chessy and Frammont in France, and at Volterra and Temp
(Delesse, Ann. Ch. Phys. [3] xviii. 478). It is very variable in co
probably a mixture of several minerals.

BURETTE. See Analysis, Volumetric (p. 256).

BURGUNDY PITCH or **RESIN.** *Poix de Bourgogne*, *Pix a*
is the white pitch obtained from pine-wood. The resin of *Pinus p*
repeated boiling with water, is also called *Burgundy pitch.* (See
Pitch.)

BURSERA GUMMIFERA. *Gommart.*—A terebinthaceous
the Antilles. It yields a dry white resin having a crystalline fractu
of turpentine, also like that of elemi. It is but slightly fusible, b
through boiling water in small tenacious granules. The resin dist
yields 47 per cent. of a coloured volatile oil (*Gommart-oil*, *Essen*
which, when purified by standing in contact with potash, then with
rectification, has the same odour, composition, and vapour-density as
and forms with hydrochloric acid, two compounds, one of which is cry
sists of $C^{10}H^{16}\,2HCl$. (H. Deville, Ann. Ch. Phys. [3] xxvii. 90.)

BUSTAMITE. Native silicate of manganese. See Rhodonite.

BUTEA GUM. *Bengal Kino*—The juice of *Butea frondosa*, Rox

d of genuine kino. It forms black-brown, slightly lustrous, brittle
ingent taste, and yields pyrocatechin by dry distillation.

D. A solid fatty acid, which Heintz obtained (Pogg. Ann. xc.
ure, by partially precipitating an alcoholic solution of the solid fatty
acetate of magnesium, this acid then forming the less soluble com-
of opinion that in the pure state it would have the composition of
$H^{40}O^2$. (See p. 353.)

he fatty non-azotised constituent of milk. It is suspended in the milk
, and rises to the surface, when the milk is left at rest, in the form of
th a certain quantity of casein and the other constituents of the milk.
from cream by agitation or *churning*, which causes the fat-globules
masses and separate completely from the watery liquid, called
er thus obtained and in the state in which it is commonly used, consists
al butter and $\frac{1}{5}$ of butter-milk, from which it may be separated by
l vessel at about 60° C., decanting the clear fat which floats at the
with water at 40° C. Ordinary butter from cow's milk, is com-
o Chevreul, of stearin, margarin, and olein, with small quantities of
nd caprin, to which its odour is due. According to Heintz, it con-
e quantity of palmitin, and a small quantity of stearin, together
antities of glycerides, yielding by saponification myristic acid and
^{2} (*vid. sup.*)

in 28 pts. of boiling alcohol of specific gravity 0·82. It is very
, a change which consists in the separation of the fatty acids from
may be prevented to a certain extent by salting or by melting it, so
foreign matters which induce the decomposition.

ople, the butter brought from the Crimea and the Kirban, is kept
it while fresh over a very slow fire, and removing the scum as it
butter in this manner, and then salting it, it may be kept good
two years; moreover, this melting, if carefully done, injures neither
ur. Thénard too recommends the same method. He directs the
done on a water-bath, or at a heat not exceeding 140° Fahr.; and
l all the caseous matter has subsided to the bottom, and the butter
is then to be decanted, or strained through a cloth, and cooled in
ded ice and salt, or at least in cold spring water, othewise it will
crystallising, and likewise not resist the action of the air so well.
ssel, and in a cool place, it will thus remain six months or more,
at first, particularly after the top is taken off. If beaten up with
ight of the cheesy matter when used, it will in some degree resemble
ppearance. The taste of rancid butter, he adds, may be much cor
and cooling in this manner.

of curing butter, is as follows: Take one part of sugar, one of nitre,
st Spanish great salt, and rub them together into a fine powder.
is to be mixed thoroughly with the butter, as soon as it is com-
the milk, in the proportion of one ounce to sixteen; and the butter
o be pressed tight into the vessel prepared for it, so as to leave no
tter does not taste well, till it has stood at least a fortnight: it then
flavour, that no butter ever acquires; and with proper care may be
his climate, or carried to the East Indies, if packed so as not to melt.
the interior of Africa, Mungo Park informs us, there is a tree much
erican oak, producing a nut in appearance somewhat like an olive.
nut, by boiling in water, affords a kind of butter, which is whiter,
her flavour than any he ever tasted made from cows' milk, and will
the whole year. The natives call it *shea toulou*, or tree butter.
f it are made every season." U.

argely adulterated with water and salt, which are introduced while
e melted state and incorporated by stirring till the whole is cold.
water may be determined very nearly by melting a portion of the
glass vessel, such as a common ounce phial, and leaving it to stand
ll the water settles to the bottom. The quantity of the water should
ent. The amount of salt is determined by calcination, any quantity
may be regarded as adulteration. Butter is also frequently adul-
in places where that kind of fat is cheap. (For the preparation of
Dictionary of Arts, Manufactures, and Mines, also *Muspratt's Che-*

ANTIMONY, TIN, &c. Old names for anhydrous metallic
buttery consistence.

BUTYL and derivatives. Syn. TETRYL and derivatives.

BUTYLACTIC ACID. *Oxybutyric acid.* $C^4H^8O^3 = (C$
Wurtz, Ann. Ch. Pharm. cvii. 197.)—This acid has hitherto been ol
oxidation of amyl-glycol (p. 208); but it might doubtless be pro
oxidation of butyl-glycol, as well as by other processes. It is
heating 14 pts. of amyl-glycol with 30 pts. nitric acid (HNO^3) and
evaporating over quick lime; it then remains in the form of a syru

Butylactic acid bears to butyric acid the same relation that lacti
pionic acid, and in consequence of this relation, it is regarded as
ACID), although all the salts yet obtained from it contain but one
place of hydrogen. The *barium-salt*, $Ba''(C^4H^7O^3)^2$, is uncrystallis
proportions, and with moderate facility, in dilute alcohol, but is in
alcohol; ether precipitates it from the alcoholic solution. The *calcium*
(dried at 120° C.), separates from the aqueous solution by spontane
warty crystals, which dissolve readily in water and in absolute a
soluble in ether. The *zinc-salt*, $Zn''(C^4H^7O^3)^2 + 2aq.$, crystallises
which dissolve in 160 pts. of water at 15° C., but are insoluble in ab
crystals are permanent in the air, but give off 11 per cent. (2 at.)

BUTYRACETIC ACID. *Pseudo-acetic Acid.* $C^3H^6O^2$ or C
acid first obtained by Nöllner in 1841 (Ann. Ch. Pharm. xxxviii.
of the fermentation of a mother-liquor from the preparation of tarta
a considerable quantity of tartrate of calcium, or by converting cru
pure tartrate of calcium, and fermenting the product. Nöllner de
pseudo-acetic acid, from its resemblance to acetic acid. Berzeliu
mixture of acetic and butyric acids. Nicklès, however (Compt.
showed that, although this acid is easily resolved into acetic and b
nevertheless a distinct acid, and gave it the name butyraceti
Malaguti, and Leblanc (Compt. rend. xxv. 781), showed tha
composition and boiling point with propionic acid, which it also res
physical properties, and moreover stated that its salts are ident
pionates in composition and crystalline form. Nicklès, on the othe
that the salts differ in certain respects from the corresponding pr
the acid has been examined by Limpricht and v. Uslar (Ann
321), who have shown that butyracetate of barium yields, by dry di
propione, and propylene (tritylene), in which respect it exactly resem
but that, on the other hand, butyracetic acid separates spontaneousl
into acetic and butyric acids, which is *not* the case with propionic ac
therefore, butyracetic acid must be regarded as a distinct acid. It
duced only by the fermentation of tartrate of calcium; acid tart
whether crude or purified, yields by fermentation nothing but aceti
to later experiments of Nicklès (J. Pharm. [3] xxxiii. 351), it is
by pouring a mixed solution of equivalent qualities of an acetate a
dilute sulphuric acid.

Butyracetic acid resembles propionic acid in most of its propertie
proportions with water, and is separated therefrom unaltered by ch
property which distinguishes it from a mere mixture of butyric
According to Dumas, it boils constantly at 140° C.; but, according
v. Uslar, it begins to boil at 120°, at which temperature nearly pur
over, and the boiling point gradually rises to 160°, when butyric ac
boiling point not remaining stationary for any time at 140°. It doe
definite anhydride or a definite ether, but in both cases a mixt
butyrate.

Butyracetate of Barium, $Ba''(C^3H^5O^2)^2 + aq.$, resembles the propio
and properties; but on decomposing it with sulphate of copper, the
free separates into butyric and acetic acids (Nicklès). The *calcium-*
forms silky needles, or, according to Nicklès, regular octahedrons,
the air. The *copper-salt* crystallises in dark blue-green tables, whi
their water of crystallisation at 100° C. It rotates on water, dis
water, more easily in alcohol.

The *neutral lead-salt* crystallises from a very concentrated soluti
tures in cauliflower-like masses. It melts when heated, giving of
and deliquesces in moist air. A concentrated solution, to which ch
added as long as the precipitate first formed disappears on agitati
evaporation, a double salt which crystallises in square prisms cont
lead, and likewise chlorine. The *basic lead-salt* is formed by boi
with oxide of lead. It crystallises from a moderately concentrated
above 0° C., in octahedrons which contain 42 per cent. water, unde

issolve readily in alcohol. From a very concentrated solution or from
ses in tables; at very low temperatures, however, in spherical seg-
en gently heated, split from the centre outwards with a slight noise.
oiling solution of the lead-salt with a little ammonia, a crystalline
tated. (Nöllner.)

salt crystallises in satiny scales, which are reddened by light. The
ystallises in very deliquescent thin tables. The *silver-salt* separates
boiling solution of the ammonium-salt, mixed with a boiling solution
er, in shining needles resembling acetate of silver and sparingly
The *sodium-salt* crystallises from a somewhat dilute solution in
edrons; from a more concentrated solution, as a white tallowy amor-
a radio-crystalline mass. The *zinc-salt* is soluble in water, but de-
ing.

and BUTYRALDEHYDE, C^4H^8O. — Two compounds are known
omposition of the term in the butyric series corresponding to that of
cetic series; they are not, however, identical.

obtained by Chancel (Ann. Ch. Phys. [3] xii. 416), among the pro-
ructive distillation of butyrate of calcium. The crude product of this
xture of several substances, of which butyral, boiling at 95° C. is the
can be separated from the others by fractional distillation.

a colourless, very mobile liquid, with a burning taste, and a sharp
dour. Its density at 22° C. is 0·821, and it boils at 95°. It dissolves
of water. It is slightly soluble in water, and soluble in all proportions
and wood-spirit. It rapidly absorbs oxygen from the atmosphere,
into butyric acid. It is oxidised by solid chromic acid with a slight
very inflammable and burns with a brilliant flame. Heated with
of silver, it reduces part of the oxide to the state of metallic silver,
remaining in solution. On heating it with sulphuric acid, sulphurous
and a small quantity of butyric acid remains in solution. By dilute
converted into nitropropionic acid. It forms crystalline compounds
es of alkali-metals, analogous to those which aldehyde forms. By the
loride of phosphorus on butyral, hydrochloric acid, oxychloride of
a peculiar product, C^4H^7Cl, are formed:

$$C^4H^8O + PCl^5 = C^4H^7Cl + HCl + POCl^3.$$

colourless, oily, very mobile liquid, lighter than water, with a sharp
g taste. It is insoluble in water, but soluble in alcohol and in ether.
tle over 100° C.; it is inflammable, and burns with a green-edged
obable that the action of pentachloride of phosphorus on butyral is
action on aldehyde, and gives rise to the compound $C^4H^8Cl^2$,
chloride of ethylidene (p. 107), and that at the moment of its
ubstance is decomposed into hydrochloric acid and the body above

Derivatives of Butyral. — Chlorine acts very energetically on
formation of definite compounds containing chlorine in the place of

d Butyral. C^4H^7ClO.—Produced by passing a current of dry chlorine
y diffused light. The gas is at first absorbed, with evolution of heat
ation; afterwards the colour disappears and the liquid gives off torrents
cid gas to the end of the operation. A rapid current of carbonic
passed through the liquid heated somewhat below its boiling point,
ectified. It is a transparent limpid liquid, heavier than water;
has a pungent tear-exciting odour. It is insoluble in water, but
ol, and its alcoholic solution does not cloud nitrate of silver. It does
e with ammonia.

Butyral, $C^4H^6Cl^2O$.—When dry chlorine is passed for three hours
xposed to sunlight, the action is observed to slacken after some time.
ride be now passed through the liquid, which is afterwards rectified, a
ined boiling at 200° C.

d Butyral, $C^4H^4Cl^4O$. — Chlorine is passed for several days through
o bright sunshine, the liquid being ultimately heated, and the action
as hydrochloric acid gas continues to be evolved. When purified
bstances, it forms a thick heavy neutral oil, which boils at a high
decomposition.

de. $C^4H^8O = C^4H^7O.H$.— This body was obtained by Guckelberger
ts of the action of oxidising agents on fibrin, albumin, and casein.

For the full details of the process, Guckelberger's paper must be refe Pharm. lxiv. 39). The crude distillate resulting from the action wa chalk and distilled. A neutral distillate was obtained which cons hydes of the acetic, propionic, butyric, and benzoic series. These w fractional rectification, the portions between 70° and 100° C. w butyric aldehyde mixed with a little propionic aldehyde, being col Butyric aldehyde is much less soluble in water than propionic aldel separated from it by agitation with water. To obtain the butyrald it is agitated with ammonia, with which it forms a crystalline co decomposed by the addition of a concentrated solution of alum, the lic the distillate rectified over chloride of calcium.

When pure, it is a thin, colourless, transparent oil, which has th 0·80 at 15° C. It boils at 68° to 75°, and has an ethereal, somewhat The small quantity in which this substance has been found, has p plete investigation; but almost all its properties, as far as they hav are identical with those of butyral. It acidifies in the air; an mixed with ammonia, and then with nitrate of silver until the alka appears, gives, on the application of heat, a beautiful coating of met sides of the vessel. It differs from its isomer chiefly in its boiling and in forming a crystalline compound with ammonia, which butyral

Butyraldehyde-ammonia. $NH^3.C^4H^8O + 5aq.$ — Butyraldehyde f ammonia, a crystalline mass consisting of small acute rhombic octa alcoholic solution, the compound crystallises in large rhombic tables. do not alter in the air, but in the moist state they gradually becom heated, they melt, and sublime at a few degrees above 100° C.; more they give off ammonia. Potash does not expel ammonia from them peratures. Aqueous acids or alum separate butyraldehyde. Butyra is almost insoluble in water, but soluble in alcohol, and in ether.

Sulphuretted hydrogen passed into a solution of this body, appea pound homologous with thialdine. When the liquid resulting fr treated with ether, a sulphuretted oil is obtained, which forms with a solid crystalline compound.

BUTYRAMIDE. $C^4H^9NO = \left.\begin{matrix}C^4H^7O\\H^2\end{matrix}\right\}N.$ This compound, acetamide, is prepared by placing 1 pt. of butyric ether, and 6 pts. ammonia, in a flask, and frequently agitating the mixture until the which generally takes from eight to ten days: the liquid is then e third, and on cooling the butyramide crystallises out:

$$\underset{\text{Butyric ether.}}{C^4H^7(C^2H^5)O^2} + NH^3 = \underset{\text{Butyramide.}}{C^4H^9NO} + \underset{\text{Alcohol.}}{C^2H^6O}$$

It crystallises in snow-white, nacreous, transparent tables, which m colourless liquid, and volatilise without residue. It has a sweet, c bitter aftertaste. It is readily soluble in water, also in ether an vapour is inflammable. Passed over red-hot lime, or distilled with phoric acid, it loses water and yields butyronitrile (cyanide of trityl

$$\underset{\text{Butyramide.}}{C^4H^9NO} - H^2O = \underset{\text{Butyronitrile.}}{C^4H^9N}$$

Its aqueous solution is decomposed by boiling with fixed alkalis, yield an alkaline butyrate:

$$C^4H^9NO + KHO = C^4H^7KO^2 + NH^3.$$

By pentachloride of phosphorus, it is converted into cyanide of t of phosphorus, and hydrochloric acid:

$$C^4H^9NO + PCl^5 = C^4H^7N + POCl^3 + 2HCl.$$

It is decomposed by nitrous acid, with formation of butyric acid, wa

$$\underset{\text{Butyramide.}}{C^4H^9NO} + \underset{\text{Nitrous acid.}}{HNO^2} = \underset{\text{Butyric acid.}}{C^4H^8O^2} + H^2O + N^2$$

Mercuric Butyramide. $Hg''(C^4H^7NO)^2$, is obtained by boiling merc lution of butyramide. The filtered solution, when concentrated, depo in small nacreous crystals, more lustrous than butyramide, which t semble.

BUTYRIC ACID. $C^4H^8O^2 = \left.\begin{matrix}C^4H^7O\\H\end{matrix}\right\}O.$—Butyric acid is a

ty acids, of the general formula $C^nH^{2n}O^2$. It was discovered by
ised it by saponifying butter with alkalis. It occurs in nature both
d in combination with bases. It is found in perspiration, in the
m human flesh, and from that of animals; in crude oil of amber;
It is found in all liquids containing lactic acid, as a product
on of this substance. Butyric acid is also contained, together with
of the same series, in combination with glycerin, in butter from
ilk. This compound of butyric acid with glycerin is inodorous,
composition on standing, by which butyric acid is set free, that
butter is chiefly due. Butyric acid is a frequent product of the
c substances, as when fibrin is treated with sulphuric acid and
ese, or when oleic acid is oxidised by nitric acid. It has also been
oducts of the destructive distillation of tobacco (Zeise) and of peat
ber. d. Chem. 1858, 280). Lastly, it has been found in several
beetles, and in certain mineral waters. (Gm. x. 76; xiii. 388;
. [2] 561.)

int mode of its formation, and that on which the present methods
tion are based, depends on the metamorphosis which starch, sugar,
presence of substances which act as ferments. Pelouze and Gélis
utyric acid can be obtained from all amylaceous and saccharine
be transformed into lactic acid, such as cane-sugar, milk-sugar,
These substances exposed in water to a temperature of 25° to 30° C.
cheese, or some other decaying nitrogenous substance, first undergo
tion, and are ultimately converted into butyric acid. This latter
ith disengagement of carbonic anhydride and hydrogen:

$$\underset{\text{Lactic acid.}}{C^6H^{12}O^6} = \underset{\text{Butyric acid.}}{C^4H^8O^2} + 2CO^2 + H^4.$$

ess given by Pelouze and Gélis, has subsequently been modified by
hod is essentially as follows: 6 lbs. of cane-sugar and ½ an oz
dissolved in 26 lbs. of boiling water, and left to stand for some
ane-sugar to pass into grape-sugar. To this solution, about 4 oz.
diffused in 8 lbs. of sour skim-milk, together with 3 lbs. of chalk,
whole is left in a place the temperature of which is uniform at about
nixture is frequently stirred, and generally solidifies after ten or
ick mass of lactate of calcium. If this be allowed to stand under
, the evaporated water being renewed, it again becomes liquid, gas
at the expiration of five to six weeks, when the disengagement of
whole of the lactic acid (and therefore the whole of the sugar), has
acid, which is present as butyrate of calcium. The operation seems
large quantities of substance.

on of butyrate of calcium is mixed with an equal bulk of water, and
pounds of crystallised soda is added, with agitation. The solution
carbonate of calcium is evaporated to ten pounds, and decomposed
tion of five and a half pounds of sulphuric acid, previously diluted
nt of water. The greater part of the butyric acid then separates as
surface of the solution of the acid sulphate of sodium, and is re-
a tap-funnel. In order to obtain the butyric acid still contained in
ate of sodium, it is distilled, the distillate neutralised with carbonate
ted, and the acid separated as before by means of sulphuric acid.

ions of crude butyric acid, which, besides water, always contain
sodium, are mixed with sulphuric acid (about one ounce to one
prevent the separation of neutral sulphate of sodium, which would
istillation. The distillate consisting of aqueous butyric acid is
hloride of calcium, and rectified. At first, dilute acid passes over
ces of hydrochloric acid; this afterwards gives place to concentrated
actionally distilled, is obtained of a constant boiling point and quite
to use sulphuric than hydrochloric acid in the decomposition of
, as the latter causes the mixture to froth up, and it is difficult to
d completely from hydrochloric acid.

also be prepared by saponifying butter with an alkali, and distilling
uric acid. But this method is never used for the preparation of
s its separation from the accompanying soluble fatty acids is very
some.

tyric acid, when pure, is a colourless, transparent, and very mobile
dour suggestive both of vinegar and of rancid butter. It has a
ing taste, and attacks the skin like the strongest acids. It boils at

157° C. under 760 mm. pressure (Kopp), and distils without alter
density varies with the temperature; at 261° C. it was found to be
to 2 vols. The vapour is inflammable, and burns with a blue fla
of the liquid acid is 0·9886 at 0° C.; 0·9739 at 15°; and 0·9675
not solidify at 20°, but in a mixture of solid carbonic acid and et
in plates. Butyric acid is soluble in all proportions in water, a
spirit.

Decompositions.—1. Butyric acid dissolves in *sulphuric acid* wit
the cold; at higher temperatures, the greater part distils off unchang
solves in *nitric acid* in the cold; by prolonged ebullition with nitr
gravity 1·40, it is transformed into succinic acid:

$$\underset{\text{Butyric acid.}}{C^4H^8O^2} + O^3 = \underset{\text{Succinic acid.}}{C^4H^6O^4} + H^2O.$$

3. *Iodic acid* does not act upon butyric acid.—4. Butyric acid is ene
by *chlorine*, with formation of hydrochloric acid and of dichlo
$C^4H^6Cl^2O^2$. If the action of the chlorine be continued, the butyric
converted into tetrachlorobutyric acid, $C^4H^4Cl^4O^2$. *Iodine*
action on butyric acid.—5. By the action of *pentachloride of phosph*
butyryl, C^4H^7OCl, oxychloride of phosphorus, and hydrochloric aci

$$\underset{\text{Butyric acid.}}{C^4H^8O^2} + PCl^5 = \underset{\text{Chloride of butyryl.}}{C^4H^7OCl} + POCl^3 + HCl.$$

6. With *pentasulphide of phosphorus*, it forms thiobutyric acid (

$$5\underset{\text{Butyric acid.}}{\left(\left.\begin{matrix}C^4H^7O\\H\end{matrix}\right\}O\right)} + P^2S^5 = 5\underset{\text{Thiobutyric acid.}}{\left(\left.\begin{matrix}C^4H^7O\\H\end{matrix}\right\}S\right)} + P^2O$$

BUTYRATES.—Butyric acid is monobasic, the butyrates being re
general formula $C^4H^7MO^2 = C^4H^7O.M.O.$

When quite dry, they are inodorous; but when moist, they possess
butter. They are mostly soluble in water, and crystallisable. Mar
when thrown upon water.

Butyrate of Ammonium, $C^4H^7(NH^4)O^2$.—A deliquescent
butyronitrile, C^4H^7N, when distilled with anhydrous phosphoric aci

$\left.\begin{matrix}\textit{Butyrate of Allyl.}\\\textit{Butyrate of Amyl.}\end{matrix}\right\}$ See BUTYRIC ETHERS (p. 695).

Butyrate of Barium. $Ba''(C^4H^7O^2)^2 + 4aq.$—Obtained by ne
acid with baryta-water. The filtered solution evaporated in the
flattened prisms, which are quite transparent, and contain 2 at. w
at a temperature below 100° C., without any loss of weight, to a tr
The salt dissolves in 2·27 pts. of water at 10°, and rotates on the
butyrate of barium is crystallised from a hot concentrated solution
per cent. of water = 1 at. water of crystallisation, its formula being Ba

Butyrate of Copper. $Cu''(C^4H^7O^2)^2 + 2aq.$—According to Chevr
and Gelis, this salt contains 2 at. water; according to Liès-Bodart
is obtained by the addition of a cupric salt to a solution of butyr
The bluish-green precipitate formed is crystallised from boiling water
crystals of the monoclinic or oblique prismatic system. By prolong
water, the salt is partially decomposed into subsalt and free butyric a
tion at about 250° C., butyrate of copper is completely decomposed i
appears to be pure butyric acid, a gas composed of equal volumes
and carburetted hydrogen, and a residue of finely divided metallic c
carbon. When butyrate of copper is rapidly heated to a high tem
produced, along with other substances, a white crystalline body,
butyrate. A compound corresponding to Schweinfurt-green (p 15
mixing a solution of butyrate of copper with solution of arsenious ac
green amorphous precipitate forms, which afterwards becomes crysta
the pure green colour belonging to Schweinfurt-green. It is a doubl
and butyrate of copper, $Cu''(C^4H^7O^2)^2.2Cu''(AsO^2)^2$.

Butyrate of Calcium. $Ca''(C^4H^7O^2)^2$ (at 140° C.).—Obtained li
Crystallises in delicate needles; melts on being heated in its water
which it gives off with tolerable facility. The dry salt, on being dist
distillate, consisting principally of butyral and butyrone. This
thrown on water. It dissolves in 5·7 pts. of water at 15°, but cryst

solution is heated, that the whole becomes solid. On cooling, it again

alcium and Barium.*—The aqueous solution of 2 pts. butyrate of cal-
butyrate of barium, deposits octahedrons of this double salt on spon-
ion.

f Iron.—Iron does not decompose dilute butyric acid, but gradually
xpense of a portion of the acid, the oxide combining with the remainder.
c salt which separates, appears to be soluble in a large quantity of

Ethyl. See Butyric Ethers (p. 695).

of Lead.—The *neutral* salt, $Pb''(C^4H^7O^2)^2$, is obtained in fine silky
ndoning the solution of lead-oxide in butyric acid to spontaneous
oil of vitriol. The same salt is precipitated by butyric acid from a
al acetate of lead, as a colourless very heavy oil, which solidifies after
Basic salt, $Pb''(C^4H^7O^2)^2.2Pb''O$. Alkaline butyrates give a copious
with solutions of subacetate of lead. When a mixture of acetic and
saturated with lead-oxide, rose-coloured crystals of basic butyrate of
These are decomposed by the carbonic acid of the air, but are held
e acetate which adheres to them.

f Magnesium. $Mg''(C^4H^7O^2)^2 + 5aq$.—Beautiful white laminæ, like
acid. The water of crystallisation is easily expelled.

Butyrate.—White shining scales, like mercurous acetate.

f Methyl. See Butyric Ethers (p. 696).

f Potassium. $C^4H^7KO^2$.—Carbonate of potassium is neutralised
utyric acid, and the solution evaporated. Crystallises in indistinct
groups. Very deliquescent; dissolves in 0·8 of water at 15° C. Ro-
There appears to be an *acid* butyrate of potassium. When butyrate
distilled with an equal quantity of arsenious anhydride, there is ob-
secondary products, an oily liquid blackened by reduced arsenic, and
karsin; it is either alkarsin or the term corresponding to it in the
. 412.)

f Sodium is like the potassium-salt, but less deliquescent.

f Silver. $C^4H^7AgO^2$.—Butyrate of potassium mixed with nitrate of
te shining scales, like acetate of silver. The salt does not deflagrate
t leaves metallic silver mixed with a little charcoal.

f Strontium. $Sr''(C^4H^7O^2)^2$ (dry).—Long flat needles like the barium-
oluble in 3 pts. of water.

f Zinc. $Zn''(C^4H^7O^2)^2$.—Aqueous butyric acid dissolves carbonate of
temperatures; the filtered solution evaporated in vacuo leaves shining
The aqueous solution is decomposed by repeated evaporation into
ree butyric acid.

Substitution-derivatives of Butyric Acid.

ric Acid. $C^4H^6Br^2O^2$.—Cahours (Ann. Ch. Phys. [3] xix. 495) ob-
f this composition, by the action of bromine on citraconate or itaconate
which he gave the name *bromotriconic acid.* It is now commonly re-
minated derivative of butyric acid, and as such finds its description
romine is gradually added, until slightly in excess, to a solution of
otassium in 1½ pts. of water, carbonic acid is evolved, and a heavy
deposited, which is a mixture of two substances, the one an acid, the
oil. This is washed with water and treated with potash, which dis-
cid, and leaves the neutral oil unchanged. On adding dilute acid to
tion, the acid is deposited sometimes as a heavy yellowish oil, some-
stalline needles: the two substances are identical in composition.
has a slight amber colour; it has a peculiar odour, feeble at ordinary,
t higher temperatures. It is much heavier than water, in which it is
; it is quite soluble in alcohol and in ether. It is partially decom-
ation, with formation of hydrobromic acid fumes, and leaves a carbo-
e. Sometimes the oily acid changes spontaneously into a mass of
attacked by nitric acid with disengagement of red fumes. Strong
lves it, disengaging a peculiar odour, after which the addition of acid
itates an oil.
forms with *ammonia* an acid salt, $C^4H^5(NH^4)Br^2O^2.C^4H^6Br^2O^2$, which
ellowish white unctuous scales, easily soluble in water and in alcohol.
$C^4H^5AgBr^2O^2$, is obtained by adding nitrate of silver to a solution of

the ammonia-salt, as a curdy precipitate, which, after standing so
pitchy mass.

Dibromobutyric Ether.—$C^4H^5(C^2H^5)Br^2O^2$, is obtained with c
of the acid in absolute alcohol is saturated at 70°—80°C. with h
the solution is distilled; the distillate is mixed with water, and th
is washed first with dilute carbonate of soda, then with pure w
over oil of vitriol. It emits an irritating odour when heated, a

Further experiments are required to prove that Cahours' bro
true dibromobutyric acid, and it is to be regretted that its disco
fully cleared up this point. Cahours obtained the following re
obtain dibromobutyric acid directly. Bromine was added to a s
potassium, until a few drops of a brominated acid were precipit
then evaporated to dryness, dissolved in alcohol, filtered, and a f
acid added, which precipitated an acid different from butyric a
but soluble in water and in alcohol. It did not appear to be
triconic acid.

Dichlorobutyric Acid. $C^4H^6Cl^2O^2$. (Pelouze and Géli
x. 447.)—The best method of preparing this acid is to pass dry
sunshine, through about 40 grm. of butyric acid, placed in a Li
At first, the absorption is very rapid; subsequently, hydrochlor
and the liquid assumes a yellowish-green colour. The absorptio
more difficult, and the current of chlorine must be continued fo
it ceases to be absorbed. Dry carbonic acid gas is now passed
perature of 80°—100° C. to expel the hydrochloric acid: the r
tyric acid.

It is a colourless viscid liquid, heavier than water, and having a
what like that of butyric acid. It is insoluble in water, but enti
It can be distilled to a great extent without alteration, but a p
poses. It burns with a green-edged flame.

Its potassium-, ammonium-, and sodium-salts are soluble. Its
soluble.

Dichlorobutyric Ether, $C^4H^5(C^2H^5)Cl^2O^2$, is prepared by gentl
solution of dichlorobutyric acid with sulphuric acid. An oily co
an ethereal odour, is deposited, which is washed with water and

Tetrachlorobutyric Acid. $C^4H^4Cl^4O^2$. (Pelouze and C
acid is produced by the continued action of chlorine upon buty
shine: the chlorobutyric acid at first formed is ultimately co
solid, crystalline mass, which when pressed between paper, and c
is obtained in the form of white oblique, rhombic prisms, which
without decomposition, and smell like butyric acid. Its silve
sparingly soluble.

Tetrachlorobutyric Ether. $C^4H^3(C^2H^5)Cl^4O^2$.—In a solution
acid in several times its bulk of alcohol, the addition of oil c
produces a crystalline mass, which melts at a gentle heat, and sep
the heavier of which is tetrachlorobutyric ether. It has an ethe
with a green flame, giving off white fumes of hydrochloric acid.

Thiobutyric Acid, $C^4H^8OS = \left.\begin{matrix}C^4H^7O\\H\end{matrix}\right\}S$. *Sulphobutyric a*
Ch. Pharm. cix. 280.)—This acid is produced by the action of p
phorus on butyric acid (p. 691). The substances in equivalent c
together in a flask furnished with an inverted condensing appara
is violent at first, being assisted towards the end by gentle heati
tinued for several hours, the mixture is distilled, and the reddish
butyric acid and dissolved sulphur, as well as thiobutyric acid, is
distillation, the thiobutyric acid passing over at 130° C. It is
almost insupportable and persistent odour; boils at 130° C.; i
water, readily in alcohol, and dissolves sulphur with yellowish co
lead, it forms a bulky white precipitate of thiosulphate of lead,
in a large quantity of hot water, also in hot alcohol, and sep
small colourless crystals. The salt decomposes readily, with se
lead.

BUTYRIC ANHYDRIDE. *Anhydrous Butyric Acid.*

(Gerhardt, Ann. Ch. Pharm. lxviii. 127.)—The formation of
to that of the organic anhydrides in general, that is to say, it is
of chloride of butyryl on an alkaline butyrate.

y treating 4 pts. of dry butyrate of sodium with 2 pts. of oxychloride
oxychloride being added drop by drop to the butyrate, as in the pre-
anhydride. The reaction consists of two stages, the first being the
ide of butyryl and phosphate of sodium:

$$3C^4H^7NaO^2 + POCl^3 = Na^3PO^4 + 3C^4H^7OCl,$$

he formation of butyric anhydride by the action of this chloride
of butyrate of sodium. When the reaction is complete, the mass is
listillate redistilled over butyrate of sodium, in order to convert any
of butyryl. The distillate from this is finally rectified, those parts
d which boil at 190° C.; the portions which pass over below this point
cid, the formation of which cannot well be avoided, from the deli-
' the butyrate of sodium.

ydride (p. 20), butyric anhydride may be prepared by the action of
n butyrate of sodium. Five pts. of benzoic chloride are mixed with
of sodium in a retort, and distilled, and the distillate rectified, at
of sodium, and then alone.

ide is a colourless, very mobile, and highly refracting liquid, of
)78 at 12·5° C. Its odour is very strong, but not disagreeable, and
butyric ether than butyric acid. It boils at 190°, and its vapour-
ound to be 5·38. Exposed to the air, it gradually attracts moisture,
nto butyric acid. Poured into water, it does not dissolve like butyric
the surface as a colourless oil. In contact with aniline, it becomes
butyranilide (phenylbutyramide):

$$)^2O + 2(N.H^2.C^6H^5) = 2(N.H.C^6H^5.C^4H^7O) + H^2O.$$

E. A.

THERS. These compounds are formed from butyric acid by the
t. of an organic radicle, such as ethyl, methyl, &c. for 1 at. of hy-
e for the most part formed by the direct action of butyric acid on

ALLYL. $C^7H^{12}O^2 = C^4H^7(C^3H^5)O^2$.—Obtained by distilling butyrate
ide of allyl. After rectification, it is a colourless oily liquid, lighter
le in ether, smelling like butyrate of ethyl, and boiling at about
with potash, it yields allyl-alcohol and butyrate of potassium.
ofmann, Phil. Trans. 1857, p. 555.)

AMYL. $C^9H^{18}O^2 = C^4H^7(C^5H^{11})O^2$, is a liquid boiling at 17·6° C.
ic gravity 0·852 at 15°. Index of refraction = 1·402.

ETHYL. *Butyric Ether.* $C^6H^{12}O^2 = C^4H^7(C^2H^5)O^2$.—This ether is
by the action of butyric acid on alcohol, sulphuric acid being like-
is also formed, according to Berthelot, by distilling a mixture of
er, 3 pts. butyric acid, and 7 to 8 pts. sulphuric acid; but the dis-
arge quantity of free butyric acid. To prepare it, 2 pts. butyric acid
an equal weight of strong alcohol, and 1 pt. sulphuric acid is added
The liquid becomes heated, and butyric ether immediately rises to
to complete the transformation, it is necessary to heat the mixture
about 80° C. The butyric ether is then decanted, shaken up several
, finally with addition of chalk and chloride of calcium, then dried
alcium and distilled.

yl is a transparent, colourless, very thin liquid, of specific gravity
t 119° C., under a pressure of 0·7465 mm. Vapour-density = 4·04.
ble odour, like that of pine-apples, and a sweetish taste, with bitter
very sparingly soluble in water, but dissolves in all proportions in
her. It is slowly decomposed by potash, into butyrate of potassium

e of small quantities of butyric ether, the peculiar flavour of pine-
d some other fruits, is due. Its formation in the fruit receives an
on, from the readiness with which the saccharine matters present
hand, into lactic and butyric acids, and on the other, into alcohol.
d rum, known as pine-apple rum, owes its flavour to the presence
Vhen freshly distilled from molasses, rum has but little flavour, but
n keeping, owing to the fact that a small quantity of butyric acid
radually combines with the alcohol to form ether.

butyric ether is very extensively used in perfumery, and in confec-
e name of pine-apple oil. It is prepared for this purpose by the fol-
Butter is saponified by a strong solution of potash-ley; the soap is
little absolute alcohol, and to the solution is added a mixture of

alcohol and sulphuric acid, until a strongly acid reaction is set up. distilled, heat being applied as long as anything comes over with a

Butyrate of Ethylene, $C^{10}H^{18}O^4 = \left.\begin{matrix}(C^4H^7O)^2\\ (C^2H^4)''\end{matrix}\right\} O^2$, is obtaine mide of ethylene for several days to 100° C. with butyrate of silv butyric acid, exhausting the product with ether, and distilling fract

$$2(C^4H^7O.Ag.O) + C^2H^4Br^2 = 2AgBr + (C^4H^7O)^2.(C^2H$$

It is a colourless liquid, of specific gravity 1·024 at 0° C.; smells like boils at 239° to 241° C. (A. Wurtz, Ann. Ch. Phys. [3] lv. 400.)

Butyrate of Glyceryl. See Butyrins.

Butyrate of Methyl. $C^5H^{10}O^2 = C^4H^7(CH^3)O^2$. — A mixture acid with 1 pt. of wood-spirit and 1 pt. of strong sulphuric acid, be separates into two layers, the upper of which is butyrate of methy the transformation may be complete, it is well to agitate the mixture, tain it for some time at a temperature of from 50°—80° C. The p like the ethyl-compound.

Butyrate of methyl is a transparent colourless liquid of specif Boils at 102° C. Specific heat is 0·4918. Latent heat of vapou density, 3·52. It has a pleasant odour, somewhat resembling th It is scarcely soluble in water, but perfectly soluble in alcohol and i

BUTYRIDIN. This name was given by Berthelot to a comp butyric acid and glycerin, to which he at first assigned the (= $2C^4H^8O^2 + 2C^3H^8O^3 - 3H^2O$), but which he afterwards foun with dibutyrin (p. 695).

BUTYRINS. (Berthelot, Ann. Ch. Phys. [3] xli. 261.)—By t butyric acid on glycerin, a series of compounds analogous to the a They are *monobutyrin*, $C^7H^{14}O^4$, *dibutyrin*, $C^{11}H^{20}O^5$, and *tributyri* contain the elements of glycerin and butyric acid, minus those of wa tion may be thus expressed:

$$\underset{\text{Glycerin.}}{C^3H^8O^3} + \underset{\text{Butyric acid.}}{C^4H^8O^2} - H^2O = \underset{\text{Monobutyrin.}}{C^7H^{14}O^4}$$

$$\underset{\text{Glycerin.}}{C^3H^8O^3} + \underset{\text{Butyric acid.}}{2(C^4H^8O^2)} - 2H^2O = \underset{\text{Dibutyrin.}}{C^{11}H^{20}O^5}$$

$$\underset{\text{Glycerin.}}{C^3H^8C^3} = \underset{\text{Butyric acid.}}{3(C^4H^8O^2)} - 3H^2O = \underset{\text{Tributyrin.}}{C^{15}H^{26}O^6}$$

Viewing glycerin as a triatomic alcohol, we may consider the bu

$\left.\begin{matrix}C^3\overset{'''}{H}{}^5\\ H^3\end{matrix}\right\} O^3$, in which 1, 2, or 3 at. of hydrogen are replaced by th C^4H^7O.

The butyrins are decomposed by alkalis, and also by the alkaline lime, with formation of a butyrate and elimination of glycerin. D and treated with hydrochloric acid, they yield butyric ether and gl

Monobutyrin, $C^7H^{14}O^4 = \left.\begin{matrix}(C^3H^5)'''\\ H^2\\ C^4H^7O\end{matrix}\right\} O^3$. — This body is formed, proportions, by exposing a mixture of butyric acid with excess o action of the sun or of diffused daylight for several months. It is heating butyric acid with glycerin to a temperature of 200° C. for being taken not to exceed this temperature. It is a colourless, ne oily liquid, having an aromatic and bitter taste, without any after-ta it remains liquid, and as mobile as at ordinary temperatures. It rapi exposed to the air.

Dibutyrin, $C^{11}H^{20}O^5 = \left.\begin{matrix}(C^3H^5)'''\\ H\\ (C^4H^7O)^2\end{matrix}\right\} O^3$.—Whenever in the pre butyrin, the temperature exceeds 220° C., some dibutyrin appears t is best prepared by heating a mixture of glycerin and butyric acid hours. It is a colourless, neutral, oily, odoriferous liquid, of specific volatilises at 320° without perceptible alteration. Cooled down to liquid, but its fluidity diminishes. By aqueous ammonia, it is formation of butyramide.

$H^{26}O^6 = \left.\begin{matrix}(C^3H^5)'''\\(C^4H^7O)^3\end{matrix}\right\}O^6$. — This substance is formed by heating 15 times its weight of butyric acid to 240° C. for four hours. It is id, with an odour analogous to that of the preceding compounds, te, with irritating aftertaste. It is very soluble in alcohol and in water.

—A butyrin which is probably tributyrin, is contained in small , along with caproin, caprin, olein, and margarin. It has not been hese substances. According to Pelouze and Gélis, this compound tificially by gently heating a mixture of butyric acid, glycerin, and ric acid. On adding a large quantity of water, a slightly yellowish must be washed with water, in which it is insoluble. It is soluble alcohol and ether, from which solutions it is separated by the Saponified by potash, it yields glycerin and butyrate of potassium. tained pure, and is most probably a mixture of the butyrins above

E. A.

A compound formed from butyric acid and mannite in the same rins are formed from butyric acid and glycerin. Its properties ibed. (Berthelot, Compt. rend. xxxviii. 688.)

s sometimes applied to bog-butter (*q. v.*)

ORHYDRIN. By the action of hydrochloric acid on a mixture glycerin, a product (first observed by Pelouze) is obtained, which, elot (Ann. Ch. Phys. [3] xli. 303), is a mixture of the compounds nd $C^3H^5(C^4H^7O)Cl^2O$, that is to say, of chlorhydrin ($C^3H^7ClO^2$) ($C^3H^6Cl^2O$), in each of which 1 at. H is replaced by butyryl. No g these two compounds has yet been devised.

ACID. Bromeis (Ann. Ch. Pharm. xlii. 63) stated that butter d resembling oleic acid in most respects, but differing from it in acid by dry distillation. Bromeis assigned to this acid the for- It appears, however, from the experiments of Gottlieb, that it with oleic acid, and exhibits the characters observed by Bromeis en considerably altered by exposure to the air.

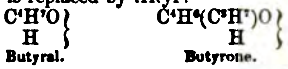
ODIC ACID. See BOG-BUTTER (p. 617).

TIC ACID. $C^7H^{12}O^4 = \left.\begin{matrix}(C^3H^4O)''\\C^4H^7O\\H\end{matrix}\right\}O^2$. — This acid, which is acid, $(C^3H^4O)''.H^2.O^2$, by the substitution of 1 at. butyryl for 1 at. yet been obtained in the free state; but Wurtz (Compt. rend. tained its *ethyl-salt*, $(C^3H^4O)''.C^4H^7O.C^2H^5.O^2$, by digesting chloro- h an alcoholic solution of butyrate of potassium in the water-bath en filtering to separate chloride of potassium, treating the filtrate cium, and rectifying:

$$\underset{\text{of ethyl.}}{H^5.Cl.O} + \underset{\text{Butyrate of potassium.}}{C^4H^7O.K.O} = KCl + \underset{\text{Butyrolactate of ethyl.}}{(C^3H^4O)''.C^4H^7O.C^2H^5.O^2}$$

of specific gravity 1·024 at 0° C., having an odour something like d, insoluble in water, soluble in alcohol, and boiling between 200° formation and constitution of this compound tend strongly to sup- at lactic acid is dibasic. (See LACTIC ACID.)

$C^7H^{14}O$.—This body is the acetone or ketone of the butyric series, omologous with acetic acetone. It represents butyral, in which 1 at. radicle is replaced by trityl:



$$\underset{\text{Butyral.}}{\left.\begin{matrix}C^4H^7O\\H\end{matrix}\right\}} \qquad \underset{\text{Butyrone.}}{\left.\begin{matrix}C^4H^6(C^3H^7)O\\H\end{matrix}\right\}}$$

alogous to that of its homologue, acetone. Butyrate of calcium in small portions is decomposed into butyrone and carbonate of

$$\underset{\text{Butyrate of calcium.}}{Ca''(C^4H^7O^2)^2} = \underset{\text{Carbonate of calcium}}{Ca''CO^3} + \underset{\text{Butyrone.}}{C^7H^{14}O}$$

antities are decomposed, the results are not so precise. The crude d of at least four substances, butyral, butyrone, and two other sub- one series. The butyrone is obtained pure by rectification, those d which boil at 140°—145° C. and these are again rectified, until nt boiling point is obtained.

Butyrone, when pure, is a colourless limpid liquid, having a odour and density = 0·83. It boils at 144° C., and its vapour-den to be 4·0, which corresponds to two volumes for the formula C by a mixture of solid carbonic acid and ether, it solidifies to a cry insoluble in water, but quite soluble in alcohol. It burns with a immediately takes fire in contact with chromic acid. It is energ nitric acid, with formation of nitropropionic acid, $C^3H^5(NO^2)O^2$, liquid, which is probably butyrate of trityl. $C^4H^7(C^3H^7)O^2$.

Distilled with pentachloride of phosphorus, butyrone yields a which Chancel terms *chlorobutyrone*. It is a colourless liquid, o lighter than water, and insoluble therein. It boils at 116° C. I does not cloud nitrate of silver.

From the crude product of the distillation of butyrate of calcium definite boiling points may be separated by treating the crude dis phite of sodium, to remove butyral and butyrone, and subjecting to fractional distillation. One of these boils at 180° C., and has 0·827. It has the formula $C^8H^{16}O^7$, which is that of methyl-buty of methyl-œnanthyl, $CH^3.C^7H^{13}O$. The latter view of its com by the fact that it yields œnanthic acid when oxidised by nitric ac pound boils at 222° C., and is a pale yellow liquid, which become composition is $C^{11}H^{22}O$, which would correspond to tetryl-butyr or tetryl-œnanthyl, $C^4H^9.C^7H^{13}O$. It appears to yield butyric by oxidation. (Limpricht, Ann. Ch. Pharm. cviii. 183.)

According to Friedel (Ann. Ch. Pharm. cviii. 125), the crude li distillation of butyrate of calcium, contains, amongst other produ $C^6H^{12}O = C^2H^5.C^4H^7O$, a colourless liquid having a biting taste like that of butyrone, specific gravity = 0·833 at 0° C., and v and a much smaller quantity of methyl-butyryl, $C^5H^{10}O = C$ gravity 3·827 at 0° C., and vapour-density 3·13.

BUTYRONITRIC ACID. This name has been applied t action of nitric acid on butyrone.

BUTYRONITRILE or **CYANIDE OF TRITYL.** C This body is best prepared by distilling butyrate of ammonium anhydrous phosphoric acid:

$$\underset{\text{Butyrate of ammonium.}}{C^4H^{11}NO^2} - 2H^2O = \underset{\text{Butyronitrile.}}{C^4H^7N}.$$

It is a transparent colourless oil, of specific gravity 0·795 at 12·6 118·5°. It has an agreeable aromatic odour resembling that of b dissolves in boiling potash, with evolution of ammonia and forn potassium:

$$\underset{\text{Butyronitrile.}}{C^4H^7N} + KHO + H^2O = \underset{\text{Butyrate of potassium.}}{C^4H^7KO^2} + NH^3.$$

BUTYRUM ANTIMONII. A name applied to trichlor account of its buttery consistence and fusibility. Other chloride have also received similar names, *e.g. Butyrum stanni*, *Butyrum*

BUTYRUREID. Syn. of BUTYRYL-UREA.

BUTYRYL. C^4H^7O.—The radicle of butyric acid and its d lowing compounds of it are known:

Bromide of butyryl	C^4H^7
Chloride of butyryl	C^4H^7
Iodide of butyryl.	C^4H^7
Hydride of butyryl (butyric aldehyde) . . .	C^4H^7
Oxide of butyryl (butyric anhydride) . . .	$(C^4H$
Hydrate of butyryl (butyric acid) . . .	C^4H^7
Butyryl-propyl (butyrone)	C^4H^7
Butyryl-urea or butyral-urea	$N^2(C$

The name butyryl has likewise been applied to the hydrocar regarded as the radicle of butyric acid.

BROMIDE OF BUTYRYL, $C^4H^7O.Br$, is produced by the action of h on butyric acid at 90°—100° C., purified by washing with wa (Béchamp.)

CHLORIDE OF BUTYRYL. $C^4H^7O.Cl$.—This body, like its ho by the action of 1 at. oxychloride of phosphorus on 3 at. butyrate of

$$\underset{\text{utyrate of sodium.}}{{}^4H^7NaO^2} + \underset{\text{Oxychloride of phosphorus.}}{POCl^3} = \underset{\text{Chloride of butyryl.}}{3C^4H^7OCl} + \underset{\text{Phosphate of sodium.}}{Na^3PO^4}.$$

rate is gradually added to the oxychloride contained in a retort:
de were at once poured on the butyrate, a large quantity of anhy-
would be formed. The mixture is distilled, and the liquid distil-
small quantity of butyrate of sodium, the temperature being kept
in order to prevent the anhydrous acid formed during the rectifica-
over with the chloride.

ryl is a colourless, mobile, strongly refracting liquid, heavier than
slightly in the air. Its boiling point is 95°. It has a pungent
yric and hydrochloric acids. It is immediately decomposed by water
nd butyric acids:

$$\underset{\text{Chloride of butyryl.}}{C^4H^7OCl} + H^2O = \underset{\text{Butyric acid.}}{C^4H^8O^2} + HCl.$$

dium it yields chloride of sodium and butyric anhydride:

$$C^4H^7OCl + C^4H^7NaO = NaCl + C^8H^{14}O^3.$$

ields butyramide and hydrochloric acid:

$$C^4H^7OCl + NH^3 = C^4H^7O.H^2.N + HCl.$$

RYL, $C^4H^7O.I$, produced by distilling butyrate of potassium with
us, is a brownish liquid, which melts in contact with the air, and
and 148° C. (Cahours.) E. A.

REA. See CARBAMIDE.

alkaloid said to exist in all parts of the box-tree (*Buxus semper-*
g to Fauré (J. Pharm. xvi. 428) it is obtained as an uncrys-
boiling the aqueous solution of the alcoholic extract of the bark
hausting the resulting precipitate with alcohol, decolorising with
d evaporating. According to Couerbe (J. Pharm. January 1854,
btained in the crystalline form by treating the sulphate with nitric
dmixed resin is destroyed or rendered insoluble, and precipitating

ter taste and excites sneezing; it blues reddened litmus-paper; is
cold water; dissolves readily in alcohol, sparingly in ether; insoluble
decomposed by nitric acid. Its salts are more bitter than the base
gelatinous precipitate with alkalis. The sulphate is said to form

(Tromm. N. J. xxv. [2] 66) obtained from box-leaves a substance
with Fauré's buxine.

A name applied to the fine capillary implanted crystals of acti-
e St. Gothard and in the Tyrol.

TILI. The bundle of threads by which the common muscle
heres to other bodies, consists, according to Scharling (Ann. Ch.
a mass resembling horny tissue, containing a small quantity of fat.
ine (J. Chem. méd. xii. 124) it contains the salts which occur in

E. A granular massive mineral occurring in large boulders near
West. The grains have one perfect cleavage and indications of
ereto. Hardness = 6 to 6·5. Specific gravity 2·80 (Thomson);
has a greenish-white colour and vitreous lustre, pearly on the
Translucent. According to Thomson (J. pr. Chem. viii. 489) it
cent silica, 29·65 alumina, 9·06 lime, 7·6 soda, 3·57 ferrous oxide,
ce it appears to be a variety of barsowite (p. 517), the alumina being
ferric oxide and the lime by soda. T. S. Hunt (Sill. Am. J. [2]
as a variety of anorthite. A dark bluish-green granular mineral
, Canada, which has been called Bytownite, is considered by the
mixture of bytownite and hornblende.

C

CABBAGE. (See Brassica.)—Infusion of red cabbage,
water on the leaves, is a convenient test for acids and alkalis.
alkali, just sufficient to neutralise the acid in the juice, tu
quantity changes the blue to green; and acids turn it red.

CABBAGIINE. A bitter principle, obtained from the
inermis, or *G. jamaicensis*), also called *Jamaicine* (*q. v.*)

CABOCLE. A mineral resembling red jasper or felsite
ferous sand of the province of Bahia. It has a density of
glass slightly; turns white before the blowpipe, but does not
in warm strong sulphuric acid, leaving a white earthy residue
acid at a higher temperature, and is precipitated therefror
(L'Institut. xxi. 78) found in the red massive mineral, phosph
baryta, ferrous oxide, and water.

CACAO. The seeds or leaves of the *Theobroma cacao*
same genus (Nat. Ord. *Sterculiaceæ*), natives of South Americ
which are extensively cultivated in those countries, and in t
and Africa, are remarkable for their nutritive properties, a
substances, cocoa and chocolate. They contain large quanti
vegetable albumin, and about 2 per cent. of an organic base,
resembling caffeine. The ash is very rich in phosphoric acid.
quality exhibit, before roasting, the following composition per
20 albumin, fibrin, &c., 2 theobromine, 10 starch, 2 cellulose,
10 water, besides small quantities of colouring matter and
Traité de Pelouze et Frémy, vi. 529.)

Cacao-beans have also been analysed by **Tuchen** (Inaug
tingen, 1857; and by A. **Mitscherlich** (*Der Cacao und die*
with the following results:

	Tuchen.				
	Guaya-quil.	Suri-nam.	Caracas.	Para.	Marag-nan.
Theobromine	0·63	0·56	0·55	0·66	0·38
Cacao-red	4·56	6·61	6·18	6·18	6·56
Cacao-butter	36·38	36·97	35·08	34·48	38·25
Glutin	2·96	3·20	3·21	2·99	3·13
Starch	0·53	0·55	0·62	0·28	0·72
Gum	1·58	0·69	1·19	0·78	0·63
Extractive matter	3·44	4·18	6·22	6·62	3·32
Humic acid	8·57	7·25	9·28	8·63	8·03
Cellulose	30·50	30·00	28·66	30·21	29·77
Ash	3·03	3·00	2·91	3·00	2·92
Water	6·20	6·01	5·58	5·55	5·48
Starch-sugar	—	—	—	—	—
Cane-sugar	—	—	—	—	—
	98·38	99·02	99·48	99·38	99·19

Mitscherlich's results do not differ from those of Payen,
pected in the analysis of different varieties; those of Tuche
from both the preceding, probably refer to the unshelled beans

The starch of cacao-beans exhibits granules of peculiar fo
those of the cereals and leguminosæ; by this means, the flour
may be detected when used to adulterate chocolate.

The ash of the shelled beans has been analysed by **Letell**
loc. cit.), and by **Zedeler** (Ann. Ch. Pharm. lxxviii. 348), wit

K^2O	Na^2O	$Ca''O$	$Mg''O$	SO^3	CO^2	P^2O^5	$3Fe^2O^3.P$
33·4		11·0	17·0	4·5	1·0	29·6	
37·14	1·23	2·9	16·0	1·5	1·2	39·6	0·17

The kernels of the theobroma are used as an article of n
natural state, or prepared in various ways. The simplest and
seeds roughly crushed, termed *cocoa-nibs*, which, however, req
as, owing to the peculiar nature of the inner seed-coating, whic

yledons, the prolonged application of heat and moisture is necessary
ents. *Flake-cocoa* is merely the seeds crushed between rollers. To
ne beans, after being carefully picked, to free them from mouldy or
are gently roasted over a fire in an iron cylinder, with holes in the
apour to escape. When the aroma begins to be well developed, the
d complete. The beans are then turned out, cooled, and freed from
ning and sifting. The husks, which often amount to 20 or 25 per
should not be thrown away, as they contain half their weight of
nous matter, which yields a tolerable nutriment. The seeds are
a paste, either by trituration in a mortar heated to 130° F., or more
hine impelled by steam, and the paste is put into moulds and sent
always improves by keeping. Sometimes the beans, before being
rot or ferment in heaps, in order to separate the kernels from the
ich surrounds them in the fruit.

different countries varies according to its mode of preparation, and
tained in it. When the kernels alone are used, or only a little sugar
te is called "Chocolat de santé." But vanilla, cloves, cinnamon,
s, are frequently added; also rice, almonds, starch, &c. Simple
preferred in this country, the perfumed sorts in France, Italy, and
onsumption is immense. (See *Ure's Dictionary of Arts, Manufac-*
.; also *Penny Cyclopædia*, art. THEOBROMA.)

Cacao-fat, is extracted from the beans by pounding them in a slightly
they are reduced to a pulp, then adding a small quantity of water,
pulp in a cloth between two plates of metal previously heated to the
ling water. It has an agreeable taste and odour, is white, semi-
ble in water, soluble, especially with aid of heat, in alcohol, ether,
ne. It has the consistence of suet, melts at 30° C., but does not
tate till cooled to 23°. It consists chiefly of stearin, with a little
more in France than in this country, for making soap, candles, and
oap made from it must not be confounded with that made from
h is a very different product, obtained from the cocoa palm (*Cocos*

colouring matter of cacao-beans. It is separated by precipitating
oholic decoction of the beans with acetate of lead, and decomposing
itate with sulphuretted hydrogen. The solution thus obtained is
r taste, and yields lilac or greyish precipitates with acetate of lead
of tin; dark green, or brown-green, with ferric salts; and green of
sometimes violet with ferrous salts; the colour of the precipitate
, according as the cacao-red in the solution is more or less mixed
ces.

cacao-red absorbs oxygen during evaporation, and becomes acid, the
ing in fact converted into a kind of tannic acid. This modified cacao-
most part, green precipitates with iron and lead salts; that obtained
cao, gives pale reddish precipitates with acetate of lead and with
n-white with sulphate of magnesium and ammonium. It is preci-
whereas unaltered cacao-red is not.

roduced by the roasting of cacao-beans, appears to affect the cacao-
of the other constituents.

JA, or **CANCHA LAGUA**, is the South American name of the
a gentianaceous plant, which, according to Bley (Arch. Pharm.
ns resin and a bitter principle.

. A variety of OPAL (*q. v.*)

NIC, or **CACHUTIC ACID.** See CATECHU.

See ARSENIDES OF METHYL (p. 403).

NE. $C^{20}H^{22}N^4O^9 = C^{20}H^{22}(NO^2)^2N^2O^5$.—A product of the decompo-
nitric acid (p. 682). It partly separates in orange-yellow crystalline
ion has ceased, and an additional quantity may be obtained by pre-
quor with alcohol. From a solution in water strongly acidulated with
rates in yellow scales. It is but very sparingly soluble in boiling
boiling alcohol, and insoluble in ether. When heated, it decomposes
anner characteristic of nitro-compounds. Exposed to diffused light
le, it soon becomes dark brown on the surface. Potash dissolves it
ellowish-brown liquid. Ammonia dissolves it immediately, forming
hich on boiling changes first to green, afterwards to brown. Caco-
metallic oxides: with baryta, it forms a soluble compound, con-

taining $2C^{20}H^{22}N^4O^9.Ba''O$. It combines also with acids, but t
posed by water. When *tetrachloride of platinum* is added to a so
in hydrochloric acid, the liquid, after a few hours, yields a crystal
taining 48 per cent. platinum = $2(C^{20}H^{22}N^4O^9.HCl).PtCl^4$.

When cacotheline is left for some hours in the red nitric solu
been formed, it changes into another body, which has the colour
insoluble in water, and explodes when heated. (Strecker, Com

CACOXENE. A native ferric phosphate, found in the
Zbiron in Bohemia, in radiated tufts of yellow or brownish-yell
brown on exposure. Specific gravity = 3·38. Hardness = 3—4
analyses. *a* and *b* are by von Hauer (Jahrb. geolog. Reichsan
Richardson (Thomson's Mineralogy, i. 476):

	P^2O^5	Fe^2O^3	H^2O	$Ca''O$	$Mg''O$
a . .	19·63	47·64	32·73	—	—
b . .	25·74	41·46	32·83	—	—
c . .	20·5	43·1	30·2	1·1	0·9

a and *c* agree nearly with the formula $2Fe^2O^3.P^2O^5 + 12$ aq., or *3fe″*
The analysis *b*, which, however, is said by von Hauer to have been
material, approaches more nearly to $3Fe^2O^3.2P^2O^5 + 20$ aq.
Steinmann, which showed 10—11 per cent. alumina, were doubtle
specimens. (Rammelsberg's Mineralchemie, p. 331.)

CACTUS. Vogel obtained from the flowers of *Cactus spe*
with weak alcohol, 30 per cent. of a carmine-red dye, insoluble
solute alcohol. The petals, after the removal of this substance,
of alcohol and ether, from 5 to 10 per cent. of a scarlet substance.
ing matters are soluble in water. (J. Pharm. **xxii.** 664.)

F. Field (Chem. Soc. Qu. J. iii. 57) has analysed the ash of a
named) growing in Chili. The fresh plant yielded 1·35, the dry
of ash, containing in 100 pts. 57·15 pts. of soluble and 42·73 of
air-dried plant yielded 85·09 per cent. water. The composition
is: 7·83 K^2O, 28·19 Na^2O, 10·65 $Ca''O$, 7·75 $Mg''O$, 0·34 Mn^2O^3,
6·40 P^2O^5, 1·38 phosphates of calcium, magnesium, and iron, and

CADET'S FUMING LIQUID. See ARSENIDES OF METH

CADIE-GUM. A very pure kind of gamboge, probably fro
bogioïdes.

CADMIUM. *Symbol* Cd. *Atomic weight* 112. Atomic vol
state = 1.

This metal is frequently found associated with zinc, and derive
mia fossilis, a denomination by which the common ore of zinc
It appears to have been discovered about the same time (1818) by
Ann. lx. 193) and by Hermann (*ibid.* **lix.** 95, 113; **lxvi.** 274),
investigation is due to Stromeyer.

Cadmium occurs in small quantity in several varieties of native
and silicate of zinc, viz. in the radiated blende of Przibram in Hun
of 2 or 3 per cent.; in the blende of Nuissière, to the amount
in silicate of zinc from Freiberg and from Derbyshire; in car
Mendip; in carbonate and silicate of zinc from the Cumberland
ores of the Harz and of Silesia. The zinc flowers obtained as a s
the smelting of the Silesian ores, contain, according to Hermann
cent. of cadmium. Commercial English zinc frequently also cont
only pure native compound of cadmium is the sulphide called
Bishopstown in Renfrewshire.

Preparation.—In the process of reducing ores of zinc, the
contain comes over among the first products of distillation, owing
tility. It may be separated from zinc in an acid solution by su
throws down the cadmium as a yellow sulphide. This sulphide
trated hydrochloric acid, affording the chloride of cadmium, from
may be precipitated by an excess of carbonate of ammonia. Carb
converted by ignition into the oxide; and the latter yields the me
one-tenth of its weight of pounded coal, and distilled in a glass o
a low red heat.

Properties.—Cadmium is a white metal, with a slight ting
strong lustre, and takes a fine polish; by exposure to the air, it
whitish-grey tarnish. It has a compact texture and fibrous fract
tallises in regular octahedrons. It is soft, though harder and

nd crackles like tin when bent; very malleable and ductile. Its
fter fusion, 8·604, after hammering, 8·6944. Specific heat 0·05669
6 (Dulong and Petit). Cadmium melts below a red heat, and
t below the boiling point of mercury without emitting any par-
density of its vapour as determined by experiment at 1040° C. is
r as unity (Deville and Troost, Ann. Ch. Pharm. cxiii. 46).
value for a condensation to 1 vol. is found by multiplying the
e density of hydrogen = 112 × 0·0693 = 7·76. Hence cadmium-
ception to the usual law of condensation (p. 441).

es in hot hydrochloric or dilute sulphuric acid, taking the place of
e acid; but its best solvent is nitric acid. The bromide, iodide,
rganic salts of cadmium, the acetate for example, are soluble in
. the carbonate, borate, phosphate, and arsenate, are insoluble in
ined by precipitation. Most cadmium-salts are colourless; they
metallic taste and act as emetics. The solutions, even of the
n litmus. Those cadmium-salts which are insoluble in water are
, hydrochloric, or nitric acid, also in ammoniacal salts.

rly all its compounds with electro-negative elements, plays the part
e, the chloride being $Cd''Cl^2$, the oxide $Cd''O$, &c.

LLOYS OF. But few alloys of cadmium are known. 100 pts.
d heat 82·2 pts. cadmium, forming an alloy having nearly the
. It is very brittle, has a fine-grained scaly structure, and a
ur. With *mercury*, cadmium forms a hard, brittle, silver-white
ystallises in octahedrons, and contains 21·7 per cent. cadmium
. *platinum* retain at a red heat 117·3 pts. cadmium = Cd^2Pt. The
r-white, very brittle, very fine-grained, and refractory in the fire.

ROMIDE OF. $CdBr^2$.—Cadmium absorbs bromine-vapour at
forming white fumes of the bromide, which crystallises on cool-
ngly heated sublimes in white nacreous laminæ. The *hydrated*
, obtained by dissolving the oxide or carbonate in hydrobromic
florescent needles, which give off half their water at 100° C., and
lting, at 200°.

ium forms crystalline compounds with the bromides of potassium,
n. The *barium-salt*, $CdBr^2.BaBr^2$ + 4aq., forms large, shining,
isomorphous with the corresponding chloride. A solution of the
m and *potassium* in equivalent proportions first yields crystals
Br + $\frac{1}{2}$aq., afterwards crystals of $CdBr^2.2KBr$; both compounds
ponding double chlorides (C. v. Hauer, J. pr. Chem. lxiv. 477;
tion of equivalent quantities of bromide of cadmium and bromide
he compound $CdBr^2.NaBr$ + $\frac{5}{2}$aq. in small, shining, six-sided
em. Gaz. 1856, p. 121.)

HLORIDE OF. $CdCl^2$.—A solution of oxide of cadmium in
elds a crystalline hydrated chloride, $CdCl^2.2H^2O$; and this when
hydrous chloride in the form of a transparent, laminated, pearly
t a heat below redness, and sublimes at a higher temperature in
us laminæ.

oride of cadmium mixed with excess of ammonia yields, by spon-
n. *diammoniochloride of cadmium*, $2NH^3.CdCl^2$, or *chloride of*
$^2H^6Cd'')Cl^2$.—A *hexammonio-chloride of cadmium*, $6NH^3.CdCl^2$, is
g dry pulverised chloride of cadmium to the action of gaseous
s off $\frac{2}{3}$ of its ammonia when exposed to the air, and is converted
ompound. (Croft, Phil. Mag. [3] xxi. 355.)

ium forms crystalline compounds with the chlorides of many other
pounds, which have been particularly studied by C. v. Hauer
477; lxvii. 169; Jahresber. f. Chem. 1855, p. 392; 1856, p. 394;
iii. 250), crystallise by evaporation from mixed solutions of the
. The following have been obtained:

alt, $2NH^4Cl.CdCl^2$ + aq., crystallises in slender needles; the
s by spontaneous evaporation transparent shining rhombohedrons

$KCl.CdCl^2$ + $\frac{1}{2}$aq.—Separates, by spontaneous or by more rapid
a solution of 2–4 at. chloride of potassium to 1 at. chloride of
lky needles, which give off their water at 100° C., and at a higher
nd give off part of their chlorine. The mother-liquor, or a solution
loride of potassium to 1 at. chloride of cadmium, yields by spon-

taneous evaporation, the salt $4KCl.CdCl^2$, in large limpid cr
soluble than the preceding.

Sodium-salt. $2NaCl.CdCl^2 + 3aq.$ (air-dried).—Small,
which give off 1 at. water at 100° C., and the remainder at 1

Barium-salt. $BaCl^2.CdCl^2 + 4aq.$—Separates from a solu
tities of the two chlorides, in large shining crystals, which a
lose half their water at 100° C., the rest at 160°, and at a r
their chlorine, and melt to a colourless liquid, which does not
Rammelsberg's determination, the crystals are monoclinic, th
making an angle of 75° 45′. Ratio of the clinodiagonal, orth
axes = 0·8405 : 1 : 0·5128. Observed faces, ∞P . ∞P∞ . (
(2P∞). Inclination of faces, ∞P : ∞P∞ = 140° 50′; ∞P : 0
137° 40′.

Strontium-salt. $SrCl^2.2CdCl^2 + 7aq.$—Crystallises from
chloride of cadmium and 1 at. chloride of strontium in
acuminated crystals.

Calcium-salts.—A solution of 3 at. chloride of calcium to 4
deposits the salt $CaCl^2.2CdCl^2 + 7aq.$ in deliquescent bevel
stellate groups. A hot concentrated solution of 2 at. chlori
chloride of calcium deposits, on cooling, large deliquescent cr
$CdCl^2 + 2aq.$

Magnesium-salts.—A solution of 1 to 2 at. chloride of cad
magnesium yields $MgCl^2.2CdCl^2 + 12aq.$ in large transp
solution of 2 at. chloride of magnesium to 1 at. chloride of ca
$CdCl^2 + 24aq.$ separates in deliquescent tabular crystals.

Manganese-salt. $MnCl^2.5CdCl^2 + 12aq.$—Crystallises from
of cadmium and 1 at. chloride of manganese, in pale rose-red

Iron-salt. $FeCl^2.2CdCl^2 + 12aq.$—Crystallises from a sol
tities of the two chlorides, in colourless prisms, which soon
exposure to the air.

Cobalt-salt. $CoCl^2.2CdCl^2 + 12aq.$—Somewhat deliquesc
of chloride of cobalt.

Nickel-salts. $NiCl^2.2CdCl^2 + 12aq.$—Crystallises by sponta
solution containing the two salts in the required proportion
and the mother-liquor, or the original solution, if it contains
of nickel, yields $2NiCl^2.CdCl^2 + 12aq.$ in large, dark green,

Copper-salt. $CuCl^2.CdCl^2 + 4aq.$—Crystallises from a
valent quantities, in slender shining prisms, grouped in tufts
when dry.

Chloride of cadmium forms double salts with the hydroc
bases. Greville Williams (Chem. Gaz. 1855, 450) ob
$C^9H^7N.HCl.CdCl^2$, as a hard crystalline mass; and othe
obtained by J. Galletly (Ed. N. Phil. J. iv. 94), viz.:

Cinchonine-salt.	$2(C^{20}H^{24}N^2O.HCl).CdCl^2 + aq.$
Morphine-salts.	$2(C^{17}H^9NO^3.HCl).7CdCl^2 + 4aq.$, and C^{17}
Narcotine-salt.	Semi-crystalline, sparingly soluble mass.
Nicotine-salt.	$2(C^{10}H^{14}N^2.2HCl).5CdCl^2$. Crystallisable.
Lutidine-salt.	$2(C^7H^9N.HCl).3CdCl^2$. Very soluble feath
Piperine-salt.	$2(C^{34}H^{36}N^2O^5.2HCl).9CdCl^2 + 6aq.$ Stra
Strychnine-salt.	$2(C^{21}H^{22}N^2O^2.HCl).CdCl^2$. Sparingly solu
Toluidine-salt.	$4(C^7H^9N.HCl).3CdCl^2 + 2aq.$ Very solub

CADMIUM, DETECTION AND ESTIMATIO
actions.—All cadmium-compounds, when heated on charco
flame with carbonate of sodium or cyanide of potassium, g
of cadmic oxide. A little cadmium, in presence of zinc, m
the mixture with carbonate of sodium for an instant in the i
incrustation of cadmic oxide will be formed. Much longer h
formation of zinc-oxide. With *borax* and *microcosmic salt*, c
which is yellowish while hot, colourless when cool.

2. *Liquid Reactions.*—*Zinc* immersed in a solution of a
metallic cadmium in dendrites. *Sulphydric acid gas*, pa
solutions, even when a large excess of acid is present, prec
cadmium in the form of sulphide, which has a lemon-yellow
wards becomes orange-yellow. A similar effect is produced
the precipitate being insoluble in excess. The hydrated sulp
cobalt, and nickel, when recently precipitated, likewise thro

nic salts (Anthon, J. pr. Chem. x. 353). *Caustic alkalis* throw down
f cadmium, very easily soluble in a slight excess of ammonia, but in-
h or soda. Sulphydric acid likewise precipitates sulphide of cadmium
n in excess of ammonia. The *neutral* and *acid carbonates* of *ammo-*
n, and *sodium* throw down white carbonate of cadmium, insoluble in
kaline carbonates. If the salt contains a large quantity of free acid,
dissolves in excess of carbonate of ammonia, but not otherwise (Stro-
phate of sodium throws down white phosphate of cadmium. *Oxalic*
c oxalates precipitate white oxalate of cadmium, insoluble in alkaline
sily soluble in ammonia. The white precipitate produced by *ferro-*
ssium, and the yellow precipitate produced by the *ferricyanide*, are
rochloric acid. The addition of hyposulphite of sodium and hydro-
es not produce a precipitate of sulphide of cadmium; neither is any
luced by chromic acid, succinic acid, alkaline benzoates, or tincture of

he only metal which forms a yellow sulphide insoluble in sulphide of

tive Estimation.—Cadmium is best precipitated from its solutions
sodium; it is thereby obtained as a carbonate, which, by ignition, yields
containing 87·5 per cent. of the metal.

on from other Elements.—From the metals of the second and fourth
n all non-metallic elements except selenium and tellurium, cadmium may
sulphuretted hydrogen; from *selenium*, *tellurium*, and the metals of
vision A (p. 217), by the insolubility of its sulphide in sulphide of
he sulphide is then dissolved by nitric acid, and the cadmium preci-
onate of sodium, as above.

, *lead*, and *mercury*, cadmium may be separated by the solubility of its
ia, or of its cyanide in cyanide of potassium: from *lead* also by sul-
from *mercury* by precipitating the latter in the metallic state by proto-
From *palladium*, it is also separated by the solubility of its cyanide
otassium; from *silver*, by precipitating that metal as chloride. From
n is separated by carbonate of ammonium, an excess of which re-
pper and not the cadmium: or better, by treating the solution of the
h excess of cyanide of potassium, which precipitates and redissolves
passing sulphuretted hydrogen through the liquid, whereby the cad-
tated, while the copper remains dissolved. (See COPPER.)

Weight of Cadmium.—Stromeyer found that 114·352 pts. protoxide
''O, yielded 14·352 O; whence 14·352 : 100 = 16 : Cd; and Cd =
4. Dumas (Ann. Ch. Pharm. cxiii. 27), from the mean of six
the quantity of nitrate of silver required to precipitate the chlorine
f cadmium, found for the atomic weight of cadmium numbers varying
112·76. He regards 112 as very near to the true value.

, FLUORIDE OF, CdF^2, is deposited from the aqueous solution on
white, indistinctly crystalline crusts. It dissolves sparingly in pure
dily in aqueous hydrofluoric acid. (Berzelius.)

, IODIDE OF. CdI^2.—Prepared either in the dry way, or by digest-
vith iodine and water. Crystallises in large, transparent, six-sided
re not altered by exposure to the air. It melts easily, and solidifies
ystalline form; gives off iodine at a higher temperature. Dissolves
and alcohol, and crystallises unchanged from the solutions. Sulphy
precipitates sulphide of cadmium from the aqueous solution.

-iodides of cadmium are known, viz. $2NH^3.CdI^2$, which is deposited in
from a solution of iodide of cadmium in hot aqueous ammonia; and
ch is a white powder produced by gently heating iodide of cadmium in
(Rammelsberg, Pogg. Ann. xlviii. 153.)

lmium and Potassium, $CdI^2.2KI$ + 2aq., crystallises in confused octa-
solution of the two iodides in equivalent proportions. In like manner
$2NH^4I.CdI^2$ + 2aq., apparently isomorphous with the potassium-salt;
aq. in deliquescent prisms; $BaI^2.CdI^2$ + aq., also deliquescent; and
q. in large crystals, which deliquesce in moist, and effloresce in dry
Chem. Gaz. 1856, p. 121.)

, NITRIDE OF. (?) When an electric current is passed through a
mmoniac, the positive pole being formed of cadmium, and the negative
m, the latter becomes covered with a spongy, lead-grey mass, which,
nd drying, has a density of 4·8; 5 grains of it gave off when heated

0·18 to 0·25 cub. in. of nitrogen gas free from hydrogen, and l
residue, containing globules of cadmium. (Grove, Phil. Mag.

CADMIUM, OXIDES OF. Cadmium forms two oxi
$Cd''O$, and a suboxide, Cd^2O. The protoxide dissolves in acids
absorption of oxygen, and forms salts of corresponding composit
$Cd''SO^4$, the nitrate $Cd''(NO^3)^2$, &c. These are indeed the on
the suboxide when treated with acids yields metallic cadmium a

Suboxide of Cadmium, Cd^2O, is obtained by heating the oxal
ing point of lead. It is a green powder, resembling oxide of chro
by heat or by acids into metallic cadmium and the protoxide.
yield metallic cadmium when treated with mercury: hence it a
compound, and not a mere mixture of the metal with the protox

Protoxide of Cadmium, or *Cadmic Oxide*, $Cd''O$.—Cadmium, h
the air, takes fire and is converted into protoxide. The same
when vapour of cadmium and aqueous vapour are passed toget
tube; but it is most easily prepared by igniting the hydrate,
It varies in colour from brown-yellow to blackish, according to th
By boiling cadmium for some time in a long-necked flask, the c
in purple crystals. Its specific gravity is 6·9502. It is quite
does not melt at the strongest white heat. It is easily reduced
blowpipe, and emits vapours of metallic cadmium, which is in
and forms a red or brown deposit on the charcoal (p. 703). I
but unites with it, forming a hydrate.

Hydrate of Cadmium, $Cd''H^2O^2$, is precipitated by potash fr
cadmic salts; it may be obtained in indistinctly crystalline wart
of aqueous ammonia on metallic cadmium in contact with iron c
absorbs carbonic acid from the air, is insoluble in the fixed alka
caustic ammonia, but not in carbonate of ammonia. It dissolv
nitric, hydrochloric, and acetic acid.

CADMIUM, PHOSPHIDE OF. Grey, with faint metall
difficult to fuse. Burns in the air with a bright flame, produc
Hydrochloric acid dissolves it, with evolution of phosphoretted

CADMIUM, SULPHIDE OF. $Cd''S$.—This compoun
of *Greenockite*, and is prepared as a pigment known by the n
It is formed with difficulty by fusing cadmium with sulphur,—m
cadmic oxide with sulphur; precipitated in yellow flakes when
alkaline sulphydrate is brought in contact with a cadmium-salt.
crystallises in double six-sided pyramids and other forms of
with cleavage parallel to the terminal and lateral edges of a six-
gravity 4·8 (Brooke), 4·908 (Breithaupt). Hardness equa
Of diamond lustre, semi-transparent, honey-yellow; yields an or
red powder; becomes carmine-red when heated. Decrepitates w
strongly (Brooke, Breithaupt). The artificial sulphide, in
is an orange-yellow powder, which, when heated to redness, b
and then carmine-red. It melts at an incipient white heat, a
ing, in transparent, lemon-yellow, micaceous laminæ. It is
temperature (Stromeyer). Specific gravity of the fused arti
(Karsten).

In dilute hydrochloric acid it dissolves with difficulty, even wh
but if the acid be strong, the sulphide dissolves with ease, eve
ratures, with violent evolution of sulphuretted hydrogen, and
sulphur. At a red heat it slightly decomposes vapour of wa
oxide of cadmium is formed (Regnault). It dissolves in nitri
of sulphuretted hydrogen and separation of sulphur. Very solu

CADMIUM-ETHYL. Cadmium appears to form with e
logous to zinc-ethyl; but it has not yet been obtained in the pu
(Chem. Soc. Qu. J. ix. 193), by heating cadmium-foil with half i
ethyl dissolved in an equal volume of ether in a sealed tube, ob
passed over in fractional distillation between 180° and 220° C., g
then brown vapours on exposure to the air, and at length took f
smoke. It smelt like zinc-ethyl, and was decomposed by wat
and formation of a white precipitate. It contained 36·8 per ce
the formula $Cd''(C^2H^5)^2$ requires 66 per cent. Hence the disti
contained about 56 per cent. of cadmium-ethyl, the remainde
iodide of ethyl, and perhaps certain hydrocarbons. (See also S
Chem. lxvii. 169.)

ESIUM. *Symbol* Cs. *Atomic weight* = 124.—An alkali-metal, the chloride
hich was discovered in 1860 by Bunsen and Kirchhoff, in the mother-liquors of
in saline-waters in Germany. Its compounds give a spectrum distinguished by
blue lines, one rather faint at about the middle of the blue space of the normal
rum, and the other much brighter, situated more towards the violet end. It was
is peculiar spectrum that the metal was discovered (page 214).*

AFFEIC ACID. See Caffetannic Acid.

AFFEINE or **THEINE.** $C^8H^{10}N^4O^2$, or $C^{16}H^{10}N^4O^4$. (Gm. xiii. 223; Gerh.
2.)—Caffeine was discovered in coffee by Runge, in the year 1820 (Materialien
Phytologie, 1821, i. 146). Oudry (Mag. Pharm. xix. 49), in 1827, found in tea a
alline subtance, which he called theine, supposing it to be a distinct compound;
Jobst (Ann. Ch. Pharm. xxv. 63) and Mulder (Pogg. Ann. xliii. 160), in 1838,
ed that it was identical with caffeine. Martius, in 1840 (Ann. Ch. Pharm.
i. 93), discovered the same substance in guarana, the dried pulp of *Paulinia sor-*
; and Stenhouse, in 1843 (Phil. Mag. [3] xxiii. 426), obtained it from Paraguay
the leaves and twigs of *Ilex Paraguayensis.* The same chemist has shown (Phil.
. [4] vii. 21) that it exists in the leaves as well as in the berries of the coffee-
t. The exact composition of caffeine was first demonstrated in 1832 by Pfaff and
big (Ann. Ch. Pharm. i. 17). Its combinations and reactions have been especially
ied by Stenhouse (*loc. cit.;* also Ann. Ch. Pharm. xlv. 366; xlvi. 227), Nichol-
(Chem. Soc. Qu. J. iii. 321), Péligot (Ann. Ch. Phys. [3] xi. 128) and Rochleder
. Ch. Pharm. lxxi. 1; lxxiii. 56 and 123). Its alkaline nature was first demon-
ed by Herzog. (Ann. Ch. Pharm. xxvi. 344; xxix. 171.)

eparation. a. From Tea or Coffee.—1. The mode of extraction generally adopted is
eat tea or coffee with boiling water and mix the infusion with subacetate of lead to
ipitate the tannin. Péligot adds subacetate of lead in excess, then ammonia.
mixture is boiled for some time, the lead-precipitate carefully washed on a filter
boiling water, the filtrate freed from excess of lead by sulphuretted hydrogen, and
a second filtration, evaporated at a gentle heat. On cooling, it yields an abun-
crystallisation of nearly pure caffeine, and an additional quantity may be ob-
ed by concentrating the mother-liquor and leaving it to crystallise.—2. Caffeine
also be obtained by saturating the free acid contained in infusion of tea or coffee
carbonate of potassium; treating the liquor with with infusion of gall-nuts; mix-
he precipitate with dry hydrate of lime; exhausting the mixture with alcohol; ex-
ng the alcohol from the filtrate by distillation; and dissolving the residue in boil-
water or boiling ether (Robiquet and Boutron, J. Pharm. xxiii. 108).—3. Five
of ground coffee are mixed with 2 pts. of slaked lime, and the mixture is ex-
sted with alcohol in a displacement apparatus. The extract is then dried, pul-
sed, and again treated with alcohol; the alcohol separated from the extracts by
llation; the fat oil which floats on the surface is removed; the watery liquid is eva-
ted to the crystallising point; and the crystals of caffeine are pressed and deco-
ed by animal charcoal: 50 kilogrammes of coffee thus treated yielded more than
grammes of caffeine (Versmann, Arch. Pharm. [2] lxviii. 148).—4. Ground
e is digested for a week with commercial benzene, which takes up caffeine and oil
offee. Both remain behind when the benzene is distilled off, and may be separated
ot water, which dissolves the caffeine and leaves it in large crystals when evapo-
d. The oil may also be dissolved out by ether, which leaves the caffeine undis-
ed (Vogel, Chem. Centralb. 1858, p. 367).—5. Payen exhausts coffee with ether,
washes it thoroughly with alcohol of 60 per cent., concentrates the solutions to a
tly syrupy consistence, and mixes them with three times their volume of 85 per
. alcohol, whereupon the liquid separates into two layers, the lower being viscid
the upper fluid. The latter, which contains the greater part of the caffeine, is
nted, and freed from the greater part of the alcohol by distillation; and the syrupy
due is mixed with one-fourth of its bulk of alcohol at 90° C., and left to itself in a
place: it then deposits crystals, which are recrystallised from alcohol. They con-
according to Payen, of caffetannate (chlorogenate), of caffeine and potassium, and
n submitted to dry distillation, yield a sublimate of caffeine (Ann. Ch. Phys. [3]
. 108).—6. Caffeine or theine being volatile, may also be prepared by sublimation.
this purpose, waste useless tea is gradually heated in a sublimation apparatus, like
used for preparing benzoic acid, but not so strongly as to decompose the theine.
of the sublimate is quite pure; the rest may be purified by recrystallisation from
er. (Heiynsius, J. pr. Chem. xlix. 317.)

ccording to the results of an extensive series of experiments made by Graham,
nhouse, and Campbell (Chem. Soc. Qu. J. ix. 33), coffee contains from 0·8 to

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* See Appendix to this volume.

1 per cent. of caffeine; tea about 2 per cent. **Stenhouse** (A
246) obtained from a sample of black tea from Kimaon on the
theine, and from another sample of good black tea 2·13 p
Péligot (Ann. Ch. Phys. [3] xi. 68), Hyson tea contains from
gunpowder tea from 2·2 to 4·1 per cent. of theine. Acco
Boutron (*loc. cit.*) Martinique coffee yields 0·36 per cent., M
Cayenne coffee 0·2 per cent. of caffeine.

b. From Guarana.—Guarana mixed with $\frac{3}{10}$ of its weight of
boiled with alcohol of 33° Beck; the filtrate is evaporated a li
oil which separates on cooling is removed; the residual alcoholi
porated; and the dry residue is heated: caffeine then sublimes,
afterwards quite white.—2. Twenty-four grammes of guarana
a quart of water; the cold solution is precipitated with basic ace
brownish-red precipitate filtered off, and repeatedly digested w
lead is separated from the filtrate by sulphuretted hydrogen.
from the sulphide of lead is evaporated in the water-bath to dr
solved in a little boiling alcohol, filtered, and allowed to cryst
thus obtained are purified by pressing and recrystallisation.
5 per cent. of caffeine. (**Stenhouse.**)

c. From Paraguay Tea.—The filtered decoction is precipitated
lead and the filtrate with basic acetate (or it is boiled with lith
canted from the precipitate is evaporated to dryness, a tough, d
mass then remaining. From this residue, caffeine may be ob
mation, or by reducing it to powder, mixing it with sand, and
After distilling off the ether, feebly coloured caffeine crystallis
by repeated crystallisation. The product amounts to 0·13 per
tea. (**Stenhouse.**)

[For a full account of the methods of preparing caffeine, s
loc. cit.]

Properties.—Caffeine crystallises from water in slender ne
of white silk, and containing 8·4 per cent. water of crystallisat
which is not given off completely at 150° C. (**Mulder**). Specific
1·23 at 19° C. (**Pfaff**). It has a slightly bitter taste, and gr
Melts at 178°, and sublimes completely at 185° in capillar
(**Mulder**). It is sparingly soluble in cold water and alco
Boiling water dissolves it more freely, and the solution solidif
The crystals which separate from ether and alcohol are anhydr

Decompositions.—1. Caffeine, when quickly and strongly *h*
composition, giving off vapours which have the odour of methy
phuric acid decomposes it after continued heating.—3. When
thick magma of caffeine and water, the crystals gradually disa
several substances is obtained, varying in composition accordin
action. With a comparatively small quantity of chlorine, t
acid, $C^6H^6N^2O^4$, methylamine and chloride of cyanogen, toget
$C^8H^9ClN^4O^2$. The formation of the three first-mentioned pro
the equation:

$$C^8H^{10}N^4O^2 + 2H^2O + Cl^4 = C^6H^6N^2O^4 + CH^3N + C$$

The resulting liquid heated in the water-bath gives off hydr
smelling like chloride of cyanogen, and granular crystals of a
ceeded (if too much chlorine has not been passed through the
in light flocks and crusts. If the action of the chlorine be p
$C^5H^6N^2O^3$, called *nitrotheine* by Stenhouse, *cholestrophane* by
parabanic acid [$C^3(CH^3)^2N^2O^3$] by Gerhardt, is produced:

$$\underset{\text{Amalic acid.}}{C^6H^6N^2O^4} + Cl^2 + H^2O = \underset{\text{Nitrotheine.}}{C^5H^6N^2O^3} + CO^2 +$$

4. Caffeine boiled with *hydrochloric acid* and *chlorate of pota*
a similar body, the aqueous solution of which colours the ski
a peculiar odour. The solution gives with ammonia the colou
alkalis and ferrous salts the colour of indigo.—5. Strong
caffeine gives off nitrous fumes, and forms a yellow liquid, wh
colour of murexid on adding a drop of ammonia (this reacti
caffeine). If the ebullition be continued, the liquid becomes c
hibits the purple colour with ammonia, and yields by evaporat
parabanic acid (nitrotheine), floating in a mother-liquor conta
amine.—6. Caffeine boiled with very strong *potash-ley* evolves
of methylamine.—7. With *soda-lime* it gives off ammonia, form

lcium, and a large quantity of cyanide of sodium. This reaction dis-
aine from piperine, morphine, quinine, and cinchonine, which do not
f sodium when similarly treated. (**Rochleder.**)

s of Caffeine.—Caffeine is a weak base: it dissolves in acids, forming
re an acid reaction, and are for the most part decomposed by evapora-
ree from acid being deposited.

te of Caffeine, $C^8H^{10}N^4O^2.HCl$, is obtained in crystals by dissolving
y strong hydrochloric acid, not diluted either with water or with alcohol,
ing by gentle evaporation. If either water or alcohol be added, nothing
rstallises out. The salt forms large, transparent, efflorescent crystals, be-
trimetric system, $\infty P . \bar{P}\infty . \infty\bar{P}\infty$. Inclination of the faces, ∞P :
0′ : $\bar{P}\infty : \infty\bar{P}\infty$ = 116° 30′.

s of caffeine, $C^8H^{10}N^4O^2.HCl.AuCl^3$, crystallises from alcohol in orange-
es (**Nicholson**). The *chloromercurate*, $C^8H^{10}N^4O^2.Hg''Cl^2$, obtained by
holic solution of caffeine with excess of mercuric chloride, forms needles
feine, soluble in water, hydrochloric acid, alcohol, and oxalic acid, nearly
ner. The *cyanomercurate*, $C^8H^{10}N^4O^2.Hg''Cy^2$, prepared in like manner
belonging to the dimetric system, sparingly soluble in cold water and
chloroplatinate, $2(C^8H^{10}N^4O^2.HCl).PtCl^4$, forms small distinct orange-
s, sparingly soluble in water, alcohol, and ether. With *chloride of*
drochlorate of caffeine forms a beautiful brown precipitate, and the
deposits yellow scales of another compound, not unlike iodide of lead.
of caffeine does not precipitate *sulphate of copper*, *dichloride of tin*,
d, or *mercurous sulphate*. Boiled with *ferric chloride*, it forms, on
n-red precipitate, perfectly soluble in water, and probably consisting of
imilar to the preceding. With *nitrate of silver*, caffeine forms the com-
$C^8H^{10}N^4O^2$, which separates on mixing concentrated solutions of caffeine
silver, in white crystalline hemispheres, adhering firmly to the sides of
is sparingly soluble in cold, more readily in hot water and alcohol; deto-
ated.

Caffeine is difficult to crystallise, and is easily decomposed by water.

Caffeine is obtained as a white precipitate when an aqueous solution of
ed in excess to aqueous tannic acid. It contains 41·9 per cent. caffeine
c acid (**Mulder**). An infusion of tea, by its tannin, also precipitates a
eine.

NE. The aromatic principle of coffee. It may be isolated by distilling
roasted coffee with water, agitating the aqueous distillate with ether,
evaporating the ether. It is a brown oil, heavier than water, slightly
ng water. An almost imponderable quantity of it is sufficient to aro-
an a quart of water. (**Pelouze et Frémy**, Traité, iv. 449.)

ANNIC ACID. *Caffeic Acid. Chlorogenic Acid.* $C^{28}H^{30}O^{17}$? (**Pfaff**,
i. 487.—**Rochleder**, Ann. Ch. Pharm. lix. 300; lxiii. 193; lxvi. 35;
Liebich, *ibid.* lxxi. 97.—**Stenhouse**, *ibid.* lxxxiii. 244.—**Payen**, Ann.
xxvi. 108.—**Gerh.** Traité, iii. 886.)—This acid exists in coffee berries
of 3 to 5 per cent. as a calcium- and magnesium-salt, and, according to
ouble salt of caffeine and potassium. According to Rochleder, it is also
guay tea. It is prepared by mixing an alcoholic infusion of coffee or
with water to separate the fatty matter; then boiling the liquid, adding
, decomposing the precipitate with sulphuretted hydrogen, and evapo-
red liquid. It forms a yellowish brittle mass, which may with difficulty
colourless, mammellated, crystalline groups. It dissolves easily in water,
l; has an astringent taste, and reddens litmus strongly. Melts when
hars, and gives off the odour of roasted coffee. By dry distillation it
nd a thick oil, which solidifies on cooling, and consists of oxyphenic acid
Strong sulphuric acid dissolves it with the aid of heat, forming a blood-
istilled with peroxide of manganese and sulphuric acid, it yields quinone
It dissolves with yellow colour in potash and in ammonia. The am-
ion in contact with the air quickly turns green, producing *viridic acid*,
(**Rochleder.**)

acid colours ferric salts green. It does not precipitate ferrous salts, but,
monia, a nearly black precipitate is obtained. It does not precipitate
r gelatin, but precipitates quinine and cinchonine. It reduces nitrate of
lar form if the liquid is heated.

of caffetannic acid is not definitely fixed. Rochleder first supposed it
, but afterwards gave the preference to $C^{14}H^{16}O^7$. **Gerhardt** (Traité,
sted $C^{30}H^{18}O^{17}$, according to which caffetannic acid would be a homologue

of gallotannic acid, $C^{27}H^{22}O^{17}$, differing from it by $8CH^2$. Pfaff suppos
acids, *caffeic* and *caffetannic ;* but Rochleder found only one, viz. caffe
traces of citric acid.

The *caffetannates* are but little known. The *potassium*-salt is an
in water, insoluble in alcohol, and turns brown from oxidation on exp
The *barium-* and *calcium*-salts are yellow, and quickly turn green on
air. The *lead*-salt is a white precipitate of very variable composition.

The *caffetannate of caffeine and potassium*, prepared as already de
forms spheroïdal groups of crystals, which become electric by friction.
soluble in water, less soluble in aqueous alcohol, nearly insoluble in
The aqueous solution turns brown when exposed to the air. They ar
dry distillation, swelling up strongly and yielding a sublimate of
heated with potash, they assume a red or orange colour. Heated with
acid, they yield a liquid of deep violet colour, with a bronze pellic
Nitric acid colours them orange-yellow.

CAÏNCIC ACID. $C^{16}H^{26}O^{7}$ (?) (François, Pelletier, and C
J. Pharm. xvi. 465.—Liebig, Ann. Ch. Phys. [2] xlvii. 185.—
Hlasiwetz, Ann. Ch. Pharm. lxxvi. 238.—Gerh. Traité, iii. 746.)—
of caïnca (*Chiococca anguifuga*, Martius), a rubiaceous plant growi
used as a remedy against the bites of serpents; also in the root of *Chioco*
a plant much used in the Antilles for the cure of syphilis and rheum

It is prepared: 1. By exhausting caïnca root with alcohol, concen
holic extract, mixing it with water, and adding milk of lime to the
it loses its bitterness. An insoluble basic caïncate of calcium is thus
is decomposed by a hot alcoholic solution of oxalic acid. The filtere
evaporated, yields caïncic acid in shining needles (Pelletier and
2. From the root of *Chiococca racemosa*, by exhausting the bark
alcohol; mixing the solution with neutral acetate of lead, which th
tannate of lead, together with some caïncate and phosphate; then tr
with subacetate of lead, which forms a yellow precipitate containing
of the caïncic acid, with only traces of caffetannic acid. This precipit
posed by sulphuretted hydrogen, and the filtrate sufficiently concent
acid is deposited in crystalline flakes, which may be purified by cry
boiling water containing a little alcohol.

Caïncic acid is inodorous; tasteless at first, afterwards very bitter;
in water and ether, very soluble in alcohol. Reddens litmus perceptil
give off 9 per cent. water at 100° C. (Liebig). When heated it s
yields a crystalline sublimate which is not bitter. Dilute acids a
convert it into quinovatic acid.

The *caïncates* are but little known; they have a bitter taste. The
of *ammonium*, *potassium*, *barium*, and *calcium* are soluble in water,
uncrystallisable. Lime-water, added to the solution of neutral cai
produces a copious precipitate of a basic salt, soluble in boiling
separates in white flakes, which are strongly alkaline. The
$C^{16}H^{24}Pb''O^{7} + H^{2}O$, is precipitated on mixing strong alcoholic solutio
and acetate of lead. There are also basic lead-salts.

CAIRNGORM STONE. Smoky quartz. See QUARTZ.

CAJEPUT, OIL OF. This oil is prepared in India by distil
Melaleuca Leucodendron (*L.*) with water. It was formerly employed
in medicine, both internally and externally, but is now but little use
met with in a pure or unchanged state, except in the hands of wh
As introduced into Europe, it possesses a light green colour, resemblin
solution of chloride of chromium, which is caused by a resinous colo
solved in it in very small quantity.

The colour of the crude oil is also partly due to copper, the prese
be accounted for, either by the use of a copper head in the distilling
Hindoos, or by intentional adulteration, resorted to for preserving th
the oil, which otherwise changes gradually by oxidation to a reddi
then becoming unsaleable for medicinal purposes. That the oil posses
of its own is proved by the fact that the colour remains after the co
the copper by sulphuretted hydrogen.

Oil of cajeput consists mainly of the dihydrate of a hydrocarbon ca
isomeric with oil of turpentine. Its specific gravity is 0·926 at 10° C
it to fractional distillation, dihydrate of cajputene, which constitutes
of the crude oil, passes over between 175° and 178° C.; smaller fract
ducts of decomposition, are obtained from 178° to 240° and from 24

all residue is left, consisting of carbonaceous matter mixed with me-
On treating this residue with ether, a green solution is obtained, which,
d, leaves a green resin, soluble in the portion which boils between 175°
apable of restoring the original colour. (M. Schmidl, Trans. Roy.
3] 360; Chem. Soc. Qu. J. xiv. 63.)

ENE. $C^{10}H^{16}$. (Schmidl, *loc. cit.*)—This compound is obtained, to-
o isomeric hydrocarbons, isocajputene and paracajputene, by
drate of cajputene with phosphoric anhydride for half an hour, and then
liquid, whereupon cajputene passes over at 160°—165° C.; isocajputene
and paracajputene at 310°—316°.
permanent in the *air*. It is not affected by *iodine* at ordinary tempe-
higher temperature, hydrogen is evolved and a black liquid is formed.
quickly on it, producing a dark viscid oil. With *gaseous hydrochloric*
beautiful violet liquid, but no crystalline compound, even at −10° C.
dinary *nitric* and *sulphuric acids* acts upon it with violence, forming a
sin.
insoluble in *alcohol*, but dissolves in *ether* and in *oil of turpentine*.

ne, $C^{10}H^{16}$.—Obtained: 1, as above.—2, by distilling the dihydrate of
oil of vitriol. It is an oil boiling between 176° and 178° C. Its odour is
han that of cajputene, and becomes more pungent and aromatic by expo-
the oil at the same time acquiring a yellow colour. Specific gravity =
Vapour-density of (1) = 4·82; of (2) = 4·52.
ne, *gaseous hydrochloric acid*, and a mixture of *nitric* and *sulphuric acids*,
putene in the same manner as on cajputene. With *oil of vitriol*, and
huric, *hydrochloric*, or *nitric acid* (neither of which acts upon cajputene),
scid liquids.
is insoluble in *water* and in *alcohol*, but mixes in all proportions with
oil of turpentine.

ene, $C^{20}H^{32}$, obtained as above mentioned, by distilling dihydrate of
anhydrous phosphoric acid, passes over between 310° and 316° C. It is
s a lemon-yellow colour, and in certain directions exhibits deep-blue
Vapour-density, by experiment = 7·96; by calculation (2 vol.) = 9·43.
between the experimental and calculated vapour-densities is probably
osition, taking place at the high temperature required for the deter-

e oxidises rapidly in contact with the *air*, acquiring a red colour and
ence. A mixture of *nitric* and *sulphuric acids* does not act so violently
utene and isocajputene. With *hydrochloric acid gas*, it forms a dark
hich does not yield crystals, even at −10° C. It is insoluble in *water*,
of turpentine, soluble in *ether*.

CAJPUTENE, $C^{10}H^{16}Br^{4}$.—Obtained by the action of bromine on oil of
dry bromine is dropped into the rectified oil, a very brisk action takes
ides of the vessel become covered with yellow needles, which however
but if the addition of the bromine be continued till the reaction almost
thick, viscous oil is formed, which, after several weeks, deposits a
nce. By boiling the mixture with alcohol, the granular substance is
eavy oil is left behind; and the alcoholic solution, on cooling, deposits
putene as a soft crystalline substance having a fatty lustre and much
esterin.
ajputene melts at 60° C. and solidifies again at 32°. By dry distillation,
d which crystallises again in the cooler parts of the retort. It is not
ng with aqueous potash. It dissolves in ether and in boiling alcohol.
of cajeput shaken up with bromine-water, forms a red resin, from which
ce separates in small white prisms, extremely deliquescent and rapidly

tallised bromine-compound (probably a hydrobromate analogous to the
formed in the same manner as that compound (p. 713).

CAJPUTENE, $C^{10}H^{16}Cl^{2}$, is produced by the action of nascent chlorine
te (rectified cajeput oil). When the portion of the oil distilling between
C. is mixed with very dilute nitric acid, and hydrochloric acid gas is
liquid, a violent action takes place in a few minutes, chlorine and
ng evolved; and, if the passage of the gas be continued, chloride of
nately sinks to the bottom, as a limpid brown oil, which may be freed
nitric and nitrous acid by distillation over strong potash-ley. It has a
and may be kept without alteration for any length of time, but is de-

composed by distillation. Boiled with nitrate of silver, it detonates in
manner, and forms chloride of silver.

Hydrates of Cajputene. *Hemi-hydrate*, $C^{20}H^{34}O = (C^{10}H^{16})^2.H^2O$ (
monohydrate of paracajputene, $C^{20}H^{32}.H^2O$.)—Obtained by the action of oil o
oil of cajeput. When the crude oil is raised to the boiling-point in a deep o
and oil of vitriol continuously dropped into it, violent ebullition takes pla
panied, after a while, by a peculiar crackling sound. As soon as this is ob
flame must be lowered and the acid very cautiously added, till the liqui
assumes a dark colour, extending in an instant from the surface throughout
depth. The vessel must then be immediately removed from the fire, otherw
decomposition will take place, attended with evolution of sulphurous anhyd
upper oily liquid is separated from the acid on which it floats, well washed, an
and the portion which passes over from the 170° to 175° is collected an
It is an oily liquid, whose vapour-density, as found by experiment, is 5
Now the formula, $C^{20}H^{34}O$, if supposed to represent 2 volumes of vapour, gi
calculated vapour-density the number 10·04 $\left(= \frac{240 + 34 + 16}{2} \times 0{\cdot}0693\right)$,
nearly double the experimental number. Consequently, the molecule C^{20}I
sents 4 volumes of vapour, and probably splits up at high temperatures
and H^2O, each of which occupies 2 volumes. (See **Atomic Weights**, p. 46

Monohydrate. $C^{10}H^{18}O = C^{10}H^{16}.H^2O$.—This is the chief constituen
cajeput (p. 710), and passes over in the fractional distillation between 175° a
After rectification, it is a colourless oil which boils constantly at 175°, ha
gravity of 0·903 at 17° C., and vapour-density, by experiment = 5·43; by
(2 vol.) = 5·338. It dissolves in all proportions in *alcohol*, *ether*, and *oil of*
Exposed to the *air* for a considerable time, in the moist state, it changes t
liquid, which ultimately exhibits a rather strong acid reaction with litmu
dissolves in the oil, and under certain circumstances forms crystalline
(p. 712). *Bromine* acts quickly upon it, and under similar circumstances
talline compounds (p. 711). *Chlorine gas* passed into the oil raises the te
but does not appear to act upon it further; but *nascent* chlorine (evolved
hydrochloric acid gas into the oil mixed with dilute nitric acid) converts
chloride of cajputene, $C^{10}H^{16}Cl^2$. *Phosphoric anhydride* heated with the mo
takes away the whole of its water, converting it into cajputene, isocajputene
cajputene (p. 711). *Chloride of zinc* likewise dehydrates it, but less complete
sulphuric acid acts but very slowly on the oil at low temperatures; but if th
ture be allowed to rise, sulphurous anhydride is given off, and the oil blacke
mately suffers complete decomposition. If the action be checked at a certa
sulpho-acid is formed, which yields a soluble barium-salt. Oil of vitriol dr
the oil at the boiling heat, in the manner above described takes away half
forming monohydrate of cajputene. *Dilute sulphuric acid*, on the contrary,
monohydrate to take up 2 at. more water, converting it into $C^{10}H^{16}.3H^2O$
sulphuric acid converts the monohydrate into a thick brown liquid, which b
360°. *Fuming nitric acid* rapidly oxidises the oil, even at ordinary ten
forming a large quantity of oxalic acid. Ordinary nitric acid produces the
at the boiling heat, but at ordinary temperatures it acts very slowly, conv
oil into a red liquid. Distilled over *permanganate* or *acid chromate of po*
presence of sulphuric acid, it forms a thick resinous liquid. It does not ap
altered by digestion with *peroxide of lead*. In contact with aqueous *potas*
dropped into melting potash, it forms a soluble salt, the acid of which is p
as a resin by hydrochloric or sulphuric acid. Heated with *sodium*, it forms
line mass, soluble in water and alcohol, and consisting of soda and an organic
which is separated by strong acids in the form of a fragrant resin. When
of the monohydrate is passed over red-hot *soda-lime*, a yellow oil distils ov
a peculiar odour quite different from that of the monohydrate; at the
the soda-lime becomes blackened by deposited charcoal, and when treated
gives off a large quantity of carbonic anhydride. The yellow oil thus form
by distillation, a fraction boiling between 180° and 185° C. which gave in tw
79·76 and 80·03 per cent. C, 12·20 and 12·07 H, agreeing nearly with th
$C^{26}H^{24}O^{2}$, which requires 79·59 per cent. C, 12·24 H, and 7·97 O.

Trihydrate of Cajputene, $C^{10}H^{22}O^3 = C^{10}H^{16}.3H^2O$.—Produced by
of dilute sulphuric acid on the monohydrate, or on crude oil of cajeput.
dilute sulphuric acid are added to 1 pt. of the crude oil; and the mixtu
shaken for several days till the watery liquid acquires a yellowish colour, an
to itself for about ten days, whereupon it deposits crystalline tufts of the
adhering to the sides of the vessel. The crystals melt at 120° C. and solidif

On submitting them to dry distillation, an oily liquid passes over and condenses
in the colder parts of the apparatus, apparently as the unaltered trihydrate. The
ls dissolve sparingly in cold, easily in boiling alcohol.
stals having the same composition were deposited from a secondary fraction of
cajeput-oil, which distilled at 210°—230° C., and was left for a very long time
and exposed to the air. The crude oil mixed with nitric acid and alcohol,
es, in the course of seven or eight months, into a black heavy liquid in which
ls are suspended, perhaps consisting of the trihydrate. The same compound
rs likewise to be formed in beautiful long prisms, when the crystalline mass
ced by passing hydrochloric acid gas into rectified oil of cajeput is thrown into
or alcohol.

DROCHLORATES OF CAJPUTENE.—The *monohydrochlorate*, $C^{10}H^{16}.HCl$, is obtained
tilling the dihydrochlorate, and collecting apart the fraction which boils at 160° C.
product having the same composition is obtained by treating the dihydro-
te for several days with aqueous or alcoholic potash; but its odour is different
that of the product obtained by simple distillation of the hydrochlorate, and re-
es that of pelargonic ether.

e *dihydrochlorate*, $C^{10}H^{16}.2HCl$, is obtained by passing hydrochloric acid gas
gh rectified cajeput-oil, mixed with a third of its volume of alcohol or strong
us hydrochloric acid. It crystallises from alcohol in beautiful radiating tufts;
at 55° C. and solidifies again at 30°. It has no taste or smell. By dry-distil-
, it gives off hydrochloric gas at 60°, and splits into several fractions, one of
is the monohydrochlorate. It is also deprived of half its chlorine by heating
aqueous or alcoholic potash. It dissolves sparingly in cold, easily in boiling
l or ether.

DRIODATE OF CAJPUTENE. *a. Anhydrous.* $C^{10}H^{16}.HI$.—Obtained by adding a
on of phosphorus in sulphide of carbon to a solution of iodine and oil of caje-
the same liquid. The liquid becomes hot, assumes a reddish colour, deposits
xide of phosphorus, and gives off vapours, probably containing phosphoretted
gen, and after ten or twelve days deposits crystals of the hydriodate. The re-
is perhaps:

$$6(C^{10}H^{16}.H^2O) + 6PI = 6C^{10}H^{17}I + 2PH^3 + P^2O + P^2O^5.$$

rystals are deposited in cells like those of beehives, and possess a black metallic
. They are soluble in alcohol and ether, and are very stable, not being altered
by boiling with potash.

Hydrated, $C^{20}H^{36}I^2O = 2(C^{10}H^{16}.HI).H^2O$, or *Hydriodate of Hemihydrated Caj-*
, $C^{20}H^{34}O.2HI$.—If iodine be added by small quantities, and with constant
ng, to cajeput-oil till the temperature rises from 10° to 40° C., and the vessel be
mmersed in cold water, a black crystalline compound soon separates from it, and
tering, pressing the black substance between paper, and then dissolving it in
l or ether, a solution is obtained, from which the hydrated hydriodate crystallises
sms having a fine yellow-green colour and metallic lustre, and melting at 80° C.
ompound which does not recrystallise on cooling. Potash dissolves the crystals,
acting part of the iodine in the cold, and the whole when heated. The crystals
nsoluble in water, and are not decomposed thereby; they dissolve readily in
l and ether.

ALAITE. Syn. of TURQUOIS.

ALAMINE. *Native Carbonate of Zinc. Zinc-spar. Smithsonite. Galmei.* $Zn''CO^3$.
is mineral, which is one of the most abundant ores of zinc, occurs crystallised in
bohedrons with cleavage parallel to the rhombohedral faces. Ratio of principal
ondary axes = 0·8070 : 1. Inclination of terminal faces = 107° 40′. Also reni-
botryoïdal, and stalactitic, and in crystalline incrustations; likewise granular,
y, and friable. Specific gravity = 4·45; hardness = 5. It is translucent or
nsparent; white when pure, but often tinged more or less with grey, green,
own, from admixture of the carbonates of iron and manganese. Streak white.
e vitreous, inclining to pearly. Brittle, with uneven, imperfectly conchoïdal
re.

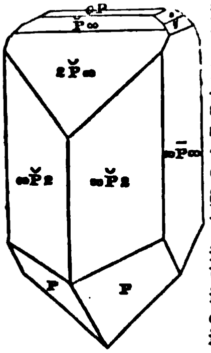
re calamine is found in Somersetshire and Derbyshire. A specimen from Somer-
ire analysed by Smithson (Nicholson's Journal, vi. 76) gave 35·2 per cent. CO^2,
34·8 ZnO, which is exactly the theoretical composition. Generally, however, a
on of the zinc is isomorphously replaced by iron, manganese, calcium, magnesium,
and copper. The following are examples: *a.* From Nertzchinsk in Siberia,
sed by Kobell (J. pr. Chem. xxviii. 480.) *b, c, d.* From Altenberg near Aix-la-
elle (Monheim, Rammelsberg's *Mineralchemie*, s. 227.) *e, f.* From Herrenberg

near Nirm, Aachen (Monheim, *ibid.*) *g.* A cupriferous variety called
Albarradon in Mexico. (Genth, Sill. Am. J. ii. xx.; J. pr. Chem. lxvi

	$ZnCO^3$	$FeCO^3$	$MnCO^3$	$CaCO^3$	$MgCO^3$	$PbCo^3$	$CuCO^3$	SiO^3	$ZnSiO$
a . .	96·00	2·03	—	—	—	1·12	—	—	—
b . .	60·35	32·31	4·02	1·90	0·14	—	—	—	2·49
c . .	55·69	36·46	3·47	2·27	—	—	—	—	0·41
d . .	84·92	1·58	6·80	1·58	2·84	—	—	—	1·85
e . .	85·78	2·94	7·62	0·98	4·44	—	—	0·09	—
f . .	74·42	3·20	14·98	1·68	3·88	—	—	0·20	—
g . .	93·74	—	1·50	1·48	0·29	—	3·42	—	—

CALAMINE, SILICEOUS. *Siliceous oxide of zinc. Hydrous si*
Zinc-glance. Kieselzinkerz. Kieselgalmei. $Zn''SiO^4 + H^2O$.—(Dana ap
mineral the name *calamine*, distinguishing the preceding as *Smithsonit*
crystals of the trimetric system. Ratio of brachydiagonal, macrodiago
cipal axis = 0·6385 : 1 : 0·6169. The crystals are short prisms (*fig.*
from the predominance of the faces $\infty\breve{P}2$ and
symmetrically terminated, viz. at one end by
and at the other by $2\breve{P}\infty$. $\breve{P}\infty$. 0P . $\frac{3}{2}P\infty$ (*y*
Inclination of faces, $\infty\breve{P}2 : \infty\breve{P}2 = 103° 53'$;
51° 34′; $\breve{P}\infty : \breve{P}\infty = 63° 20'$; 2P : 2P∞ = 101°
perfect parallel to $\infty\breve{P}2$; somewhat less, parallel to
Krystallographie, pp. 250, 264). The mineral like
stalactitic, mammillary, botryoïdal, and fibrous fo
sive and granular. Specific gravity 3·16—3·9.
4·5—5. It is white when pure, sometimes blue
coloured by oxide of iron. Transparent or transl
generally vitreous. Streak white. Brittle, with u
Like many other unsymmetrical minerals, it is p

Fig. 114.



Before the blowpipe it melts with difficulty at
is not altered by heating on charcoal, either alo
bonate of sodium; but with carbonate of sodiu
is completely reduced, with formation of a zinc-
easily decomposed by acids, with separation of ge
it also dissolves in potash-ley.

Siliceous calamine generally occurs nearly pur
from Tarnowitz in Upper Silesia, analysed by Rammelsberg, yielded 24
$Zn''O$, and 7·75 H^2O = 101·40; the formula $Zn''SiO^4 + H^2O$ or $2Zn''O$
requiring 25·1 SiO^2, 67·4 $Zn''O$, and 7·5 H^2O. Sometimes a small portio
partly replaced by iron or lead: in a specimen from Nertzschinsk in Sib
found 2·70 per cent. oxide of lead.

Siliceous calamine usually occurs, associated with the native carbonate
rocks. Large crystals are found at Nertzchinsk. (Dana, ii. 314;
Mineralchemie, s. 549.)

CALAMITE. A variety of tremolite (*q. v.*) having an asparagus-

CALCAREOUS SPAR. See Calcspar.—**CALCEDONY.** See

CALCHANTUM. Pliny's term for copperas.

CALCINATION. The fixed residues of such matters as have u
bustion are called cinders in common language, and calces, or oxides
and the operation, when considered with regard to these residues, is t
tion. In this general way it has likewise been applied to bodies not real
but only deprived of some of their principles by heat. Thus we hear of
of chalk, to convert it into lime, by driving off its carbonic acid and wa
or plaster stone, of alum, of borax, and other saline bodies, by which the
of their water of crystallisation; of bones, which lose their volatile part
ment; and of various other bodies. (See Combustion.)

CALCITE. Syn. with Calcspar (p. 721).

CALCIUM. *Symbol*, Ca. *Atomic weight*, 40.—Lime, the oxide o
been known from the earliest times, and was used by the ancients in t
of mortar. Black, in 1756, first pointed out the difference between bur
lime. The metal was first incompletely isolated by Davy in 1808, an
been obtained in the pure state by Matthiessen.

Calcium is the most widely diffused of the alkaline-earthy metals.
occurs in a great variety of forms, and, as limestone, constitutes entire mo
The sulphate, fluoride, phosphate, and silicate are also abundant nat
Less frequent are the chloride, nitrate, arsenate, and tungstate. Calci
as carbonate and phosphate in the bones of animals; the shells of mollu

composed of the carbonate. In the bodies of plants, calcium exists in combina-
various organic acids.

ration of the Metal.—Davy in 1808 obtained calcium in an impure state by
sis, similarly to barium (p. 500), and by passing vapour of potassium over red-
(?) **Matthiessen** (Chem. Soc. Qu. J. viii. 28) prepares the pure metal as
—A mixture of 2 at. chloride of calcium and 1 at. chloride of strontium, with
quantity of chloride of ammonium (this mixture being more fusible than
of calcium alone), is melted in a small porcelain crucible, in which a carbon
pole is placed, while a thin harpsichord wire wound round a thicker one, and
only just below the surface of the melted salt, forms the negative pole. The
is then reduced in beads, which hang on to the fine wire, and may be sepa-
withdrawing the negative pole every two or three minutes, together with the
ust which forms round it. A surer method, however, of obtaining the metal,
n very small beads, is to place a pointed wire so as merely to touch the surface
iquid; the great heat evolved, owing to the resistance of the current, causes
ced metal to fuse and drop off from the point of the wire, and the bead is taken
e liquid with a small iron spatula. Or, thirdly, the disposition of the appa-
y be the same as that for the reduction of strontium (*q. v.*)
Bodart and **Gobin** (Compt. rend. xlvii. 23) prepare calcium by igniting the
th an equivalent quantity of sodium in an iron crucible, having its lid screwed
According to **Dumas** (Compt. rend. xlvii. 175) it is essential that the process
cted in a closed vessel, as, under the ordinary atmospheric pressure, the sodium
ay, and the iodide of calcium remains unaltered.

rties.—Calcium is a light yellow metal, of the colour of gold alloyed with
n a freshly cut surface the lustre somewhat diminishes the yellow colour,
comes more apparent when the light is reflected several times from two sur-
alcium, or when the surface is slightly oxidised. It is about as hard as gold,
tile, and may be cut, filed, or hammered out into plates having the thickness
nest paper. Its specific gravity is 1·5778. In dry air the metal retains its
d lustre for a few days, but in damp air the whole mass is slowly oxidised.
n platinum-foil over a spirit-lamp, it burns with a very bright flash. It is not
cted on by dry chlorine at ordinary temperatures; but when heated, it burns
as with a most brilliant light; also in iodine, bromine, oxygen, sulphur, &c.
osphorus, it combines without ignition, forming phosphide of calcium. Heated
dissolves it as a white amalgam. Calcium rapidly decomposes water, and is
re rapidly acted on by dilute nitric, hydrochloric, and sulphuric acids, nitric
n causing ignition. Strong nitric acid does not act upon it below the boiling
n the voltaic circuit, with water as the liquid element, calcium is negative to
n and sodium, but positive to magnesium. It is not, however, reduced by
n or sodium from its chloride by electrolysis. On the contrary, a fused
of $Ca''Cl^2$ with KCl or NaCl, in certain proportions, yields potassium or
when subjected in a certain manner to electric action; hence it appears that
al formerly obtained by reducing chloride of calcium with potassium or
could not be calcium, but was probably a mixture of potassium or sodium
minium, silicon, &c. (**Matthiessen.**)
m unites with all the non-metallic elements, forming compounds into which it
or the most part as a diatomic radicle, *e.g.* the chloride $Ca''Cl^2$, the oxide
e sulphide $Ca''S$, &c. Most of the compounds are colourless; they have an
te, and a lower specific gravity than the corresponding compounds of barium
ntium. Of the compounds of calcium with other metals, little is known,
g that it forms an amalgam with mercury.

CIUM, BROMIDE OF. $Ca''Br^2$.—Formed by the direct union of calcium
nine, or by dissolving lime or the carbonate in hydrobromic acid. The solu-
lds by evaporation colourless silky needles of the hydrated bromide, from
e anhydrous bromide may be obtained by heating. It is deliquescent and
ble in alcohol.

CIUM, CHLORIDE OF. $Ca''Cl^2$.—This compound exists in sea-water,
ter, and spring-water, and is produced by passing chlorine over red-hot lime,
by dissolving lime or the carbonate in hydrochloric acid, and evaporating.
produced in large quantity in the preparation of ammonia by heating sal-
c with slaked lime:

$$2NH^4Cl + Ca''H^2O^2 = Ca''Cl^2 + 2NH^3 + 2H^2O.$$

due is treated with water; the solution, which is always alkaline, is neutralised
drochloric acid, and the residue evaporated to dryness.
queous solution, when highly concentrated deposits the hydrated chloride,

$Ca''Cl^2.6H^2O$, in six-sided prisms with pyramidal summits. It has a bitt
crystals give off 2 at. water when dried in vacuo, leaving the hydrate $Ca''Cl$
retains the original form of the crystals, but is opaque, and has the appe
(Graham). At 200° C. they part with the whole of their water, leavi
drous chloride in the form of a white porous mass.

The anhydrous chloride melts at a low red heat. If it be then expose
rays, it afterwards appears luminous in the dark; it was formerly call
phosphorus. When ignited in contact with the air, it is partially convert
and carbonate of calcium. Hence the porous chloride dried at about 20
adapted for absorbing water in organic analysis (p. 228) than the fused
latter, containing lime, absorbs carbonic acid as well as water.

Anhydrous chloride of calcium is exceedingly greedy of water, and
most deliquescent substances known. 100 pts. of it in powder exposed
sphere saturated with moisture absorb 124 pts. of water in ninety-six day
fore, than is required for complete deliquescence (Brandes, Schw. li.
crystallised chloride also deliquesces rapidly, and dissolves in half its we
at 0° C., in one-fourth of its weight at 16°, and in every proportion of hot
solution of the anhydrous chloride in water is attended with considerabl
heat; but the hydrated chloride in dissolving lowers the temperature
A mixture of crystallised chloride of calcium and snow produces a degre
cient to freeze mercury.

Both the anhydrous and the hydrated chloride dissolve readily in alc
of absolute alcohol at 80° C. dissolve 6 pts. of anhydrous chloride of calc
solution when evaporated in vacuo, at the winter temperature, yield
laminæ containing 59 per cent. of alcohol, agreeing with the formula 2C
The alcohol in this compound appears to take the place of water of c
It likewise forms similar compounds with methylic and amylic alcohols.

Chloride of calcium combines with *ammonia*, forming the compound
it cannot, therefore, be used for drying gaseous ammonia. It unites also
acid and with *acetate* and *oxalate of potassium*.

A solution of chloride of calcium boiled with slaked lime dissolves th
and the filtered solution deposits an *oxychloride of calcium*, $Ca''Cl^2.3Ca$
which is decomposed by pure water and by alcohol.

CALCIUM, DETECTION AND ESTIMATION OF. 1. *R*
the dry way.—The hydrated chloride and a few other calcium-compound
in the blowpipe flame on platinum-wire, impart a red colour to the fla
that produced by strontium-salts, but less intense. The colour disappea
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plate with excess of fluoride of ammonium, and gently heated till all t
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2. *Reactions in the wet way*.—The bromide, chloride, iodide, nitrate
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paration from other Elements.—From the metals of the first group
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the *alkali-metals*, calcium is easily separated either by oxalate of ammonium,
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um is separated from *barium* by precipitating both the earths as carbonates,
ng the carbonates in nitric acid, evaporating to dryness, and digesting the
in absolute alcohol, which dissolves nitrate of calcium, but not nitrate of
They may also be separated in this manner in the form of chlorides, but the
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ohol.

strontium, calcium is separated in the same manner, nitrate of strontium being
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baryta, strontia, and lime occur together, the baryta is first separated by
uosilicic acid; the strontia and lime in the filtrate are then converted into sul-
these sulphates, after being weighed, are converted into carbonates, either by
vith carbonate of sodium or by boiling with the aqueous solution of that salt;
onates weighed; and the quantities of strontium and calcium determined, as fol-
-Let x be the weight of the strontium, y that of the calcium, s that of the sul-
and c that of the carbonates; then we have the equations:

$$\frac{SrSO^4}{Sr}x + \frac{CaSO^4}{Ca}y = s; \quad \frac{SrCO^3}{Sr}x + \frac{CaCO^3}{Ca}y = c.$$

$$\text{or } \frac{183·8}{97·8}x + \frac{136}{40}y = s; \quad \frac{157·8}{97·8}x + \frac{100}{40}y = c.$$

carbonates may be dissolved in nitric acid, and the nitrates separated by
e alcohol, as above.

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acid, and ignited in hydrochloric acid gas; and the pure chloride of calcium th obtained was decomposed by nitrate of silver. Three experiments thus made gav respectively Ca = 40·00, 40·06, 40·00. The number 40 is generally adopted.

CALCIUM, FLUORIDE OF. $Ca''F^2$.—This compound occurs abundantly i nature, sometimes massive, sometimes crystallised in octahedrons, cubes, and othe forms of the regular system (see FLUOR-SPAR). It is peculiarly a constituent o metalliferous veins. In minute quantity it is very generally diffused, being associate to the amount of a few thousandths, with phosphate of calcium, in the bones of animals and in somewhat larger quantity in the enamel of the teeth; minute quantities of i also found in plant-ashes and in the earthy deposit formed in sea-water by boiling It may be prepared artificially as a gelatinous mass, by precipitating a soluble calcium salt with fluoride of potassium or sodium, or in the granular state, by neutralisin hydrofluoric acid with carbonate of calcium.

Fluoride of calcium dissolves in about 2000 pts. of water at 15° C. (G. Wilson) and somewhat more abundantly in water containing carbonic acid; hence its occurrenc in sea-water. It dissolves in free hydrofluoric acid and in strong hydrochloric aci and is precipitated as a transparent jelly by ammonia. It melts at a high temperatur and crystallises on cooling. It is decomposed at a high temperature by vapour of wate yielding lime and hydrofluoric acid. Fused with hydrate or carbonate of potas sium, or sodium, it yields oxide or carbonate of calcium and an alkaline fluorid Strong sulphuric acid does not decompose it at ordinary temperatures, but on heatin the mass, hydrofluoric acid is given off, and sulphate of calcium remains. Vapour sulphide of carbon passed over a red-hot mixture of fluor-spar and charcoal at a re heat, decomposes the fluoride completely, forming sulphide of calcium and volatil fluorine-compounds. It is also decomposed at a red heat by chlorine. (Frémy (See FLUORINE.)

Fluor-spar is much used as a flux in metallurgic operations, especially in the trea ment of copper ores; also in the reduction of aluminium (p. 151).

CALCIUM, IODIDE OF. $Ca''I^2$.—Prepared by heating calcium in iodin vapour or by dissolving lime or the carbonate in hydriodic acid, evaporating, an fusing the residue in a closed vessel. Resembles the chloride, melts below a red hea and if in contact with the air, is decomposed, with formation of lime and separatio of iodine. Very soluble and deliquescent. Decomposed by sodium at a red hea The hydrate crystallises in long needles.

CALCIUM, OXIDE OF. *Lime.* $Ca''O$.—Anhydrous or quick lime is ob tained by heating to redness the carbonate, nitrate, or any salt of calcium con taining an acid easily expelled by heat; but for actual preparation, the carbonate i the only salt employed. In a closed vessel capable of resisting pressure, carbonate o calcium may be melted without undergoing decomposition; but when heated to rednes under the ordinary atmospheric pressure, it gives off carbonic anhydride and leave lime ($Ca''CO^3 = Ca''O + CO^2$). On the small scale, the decomposition may be per formed in a crucible heated in a furnace; to obtain perfectly pure lime, the crystallised carbonate or the finest Carrara marble should be used. On the large scale, masses o limestone are burned in kilns, the mineral being mixed up with the coal or other combustible matter. In general, one bushel of coal is sufficient to make five or six bushels of lime; magnesian limestones require less fuel than pure limestone. When a limestone containing much aluminous or siliceous earth is to be burnt, great care should be taken to prevent the fire from becoming too intense; for such lime easily vitrifies. The kilns for burning these argillaceous or siliceous limestones should be provided with a damper. (See *Ure's Dictionary of Arts, Manufactures, and Mines*, ii. 729.)

Pure lime forms white hard porous masses of specific gravity 2·3 to 3·08. It bears the strongest heat without decomposition, and melts only in the flame of the oxyhydrogen blowpipe or in the voltaic arc. Its most remarkable property is the avidity with which it takes up water. When water is poured upon pure lime, it is instantly absorbed, and in a few seconds the lime becomes hot, gives off a large quantity of steam, and crumbles to powder: this is called the *slaking* of lime; with large masses the evolution of heat and escape of vapour are very violent. Lime which slakes easily, is called *fat lime*. Impure lime, especially that which contains clay, takes up water but slowly: such lime is said to be *poor*.

The product of the action of water on lime is *hydrate of calcium* or *hydrate of lime*, $Ca''H^2O^2$ or $Ca''O.H^2O$. It is a white soft powder, which gives off its water at a re heat, and is reconverted into quicklime. It is sparingly soluble in water, more in cold than in hot water: hence, water saturated with lime in the cold, deposits the hydrate when boiled. A solution evaporated in vacuo over oil of vitriol, deposits the hydrate in hexagonal prisms (Gay-Lussac). According to Dalton, lime-water formed at 60° 130°, and 212° (Fahr.) contains 1 grain of lime (anhydrous) in 778, 972, and 1270 grs.

tion, called *lime-water*, is alkaline, and has a caustic taste. It pre-
llic oxides from their solutions, all those in fact which are insoluble
bonic, boracic, silicic, and phosphoric acids when added to their
solutions, or in excess to their acid solutions. When exposed to
omes covered with a pellicle of carbonate of calcium. The solid
rbs carbonic acid from water, forming, according to Fuchs, the
$a''CO^3.Ca''H^2O^2$.
eadily in nitric, hydrochloric, and acetic acid. The hydrate exposed
lorine gas forms a mixture of chloride and hypochlorite of calcium,
loride of lime or *bleaching powder:*

$$2Ca''O + 2Cl^2 = Ca''Cl^2 + Ca''Cl^2O^2.$$

ct upon anhydrous lime or on the carbonate.
to a variety of useful purposes: —1. For making mortar. The
hydrate, is mixed with 2 pts. of coarse or 3 pts. of fine sand, and
to a paste, which as it dries, absorbs carbonic acid slowly from the
ed into a hard mass of hydrate and carbonate, which binds the
nly together. The chief use of the sand is to prevent by its mass
action of the mortar in drying. — 2. In tanning, to promote the
ir or wool from the skins, and of the fat and fleshy parts.—3. In the
stic alkalis from their carbonates. —4. In the saponification
ntended for the preparation of stearine candles.—5. In the defe
(see SUGAR).—6. As a manure. Soils containing too much clay,
th lime, which, by absorbing water and carbonic acid, swells and
thus renders the soil lighter. It also exerts a decomposing action
ng the silicate of potassium soluble.
lcium, CaO^2, is known only as a hydrate, which falls down in very
es when lime-water is mixed with an aqueous solution of peroxide
énard.)

XYCHLORIDE OF. (See page 716.)

XYGEN-SALTS OF. See the several ACIDS.

XYSULPHIDE OF. When sulphide of calcium prepared by
ate with charcoal, is boiled with a large quantity of water, the
t, and evaporated in a retort containing air, a large quantity of
gen escapes with the watery vapours: the cooled liquid deposits
, and on further concentrating the mother-liquor, gold-coloured
d consisting of an oxysulphide $Ca^6S^4O + 20 aq$. When heated out
air, they give off water and sulphur, without alteration of form. and
ue, which, when treated with hydrochloric acid, deposits sulphur,
ed hydrogen, and forms a product containing sulphate of calcium.
nn. xv. 433.)

HOSPHIDE OF. CaP^2 or Ca^2P^2?— Prepared by passing vapour
red-hot lime. A good mode of proceeding is to place a few pieces of
losed end of a combustion-tube, fill the tube with small lumps of
y forming slaked lime into pellets and calcining them), then heat
containing the lime to redness, and pass the vapour of phosphorus
y surrounding the closed end of the tube with hot fuel. To pre-
es, a crucible having a hole at the bottom is filled with pellets of
the grate of a furnace, and a flask containing phosphorus is placed
ith its neck passing upwards through the hole in the crucible. The
and as soon as the crucible is red-hot, the phosphorus in the flask
so that its vapour may pass upwards through the lime. The pro-
nass consisting, according to Thénard, of dicalcic phosphide and
e:

$$14CaO + P^{14} = 5Ca^2P^2 + 2Ca^2P^2O^7.$$

in (Handb. iii. 188), it is a mixture of monocalcic phosphide and
:

$$8CaO + P^{12} = 5CaP^2 + Ca^3(PO^4)^2.$$

reactions may take place together. The product, when thrown
diately decomposed, with evolution of spontaneously inflammable
ogen:

$$PH^3 + 3CaH^2O^2 + P^4; \text{ or } 3Ca^2P^2 + 6H^2O = 4PH^3 + 6CaO + P^2.$$

phosphide may also be decomposed in the manner represented by

$$Ca^2P^2 + 2H^2O = 2PH^2 + 2CaO.$$

The formation of the compound PH^2, may account for the spontaneous inflammability of the gas. (See Phosphoretted Hydrogen, under Phosphorus.)

CALCIUM, SELENIDES OF. A *monoselenide* is formed by precipitating chloride of calcium with monoselenide of potassium; it is a flesh-coloured precipitate. A *polyselenide*, mixed however with selenite of calcium, is produced by heating lime with selenium to a temperature just below redness. Lime-water saturated with seleniuretted hydrogen, deposits crystals of [mono ?] selenide of calcium when exposed to the air.

CALCIUM, SULPHIDES OF. The *monosulphide*, $Ca''S$, is prepared: 1. By decomposing the sulphate with charcoal or coal.—2. By decomposing the sulphate at a red heat with carbonic oxide: $Ca''SO^4 + 4CO = Ca''S + 4CO^2$.—3. By passing sulphuretted hydrogen over red-hot lime, water being formed at the same time. It is white, amorphous, with hepatic taste and alkaline reaction. It is but sparingly soluble in water: boiling water decomposes it, yielding sulphydrate and hydrate of calcium:

$$2Ca''S + 2H^2O = Ca''H^2S^2 + Ca''H^2O^2.$$

Mixed with water, it is easily decomposed by carbonic acid, yielding carbonate of calcium and sulphydric acid:

$$Ca''S + H^2O + CO^2 = Ca''CO^3 + H^2S.$$

The monosulphide, after being heated, shines in the dark; it was formerly called *Canton's Phosphorus*.

Disulphide of Calcium, Ca^2S^2, is formed by boiling milk of lime with sulphur and water, but not long enough to allow the lime to be completely saturated. The filtered liquid on cooling deposits crystals, whose composition agrees with the formula $Ca^2S^2.3H^2O$. (Herschell.)

Pentasulphide of Calcium, CaS^5, is produced when the monosulphide or hydrate of calcium is boiled for a considerable time with excess of sulphur. It absorbs oxygen with avidity. When hydrate of calcium is used, there is also formed an oxysulphide represented by the formula $Ca^6S^5O.20H^2O$ or $5CaS.CaO.20H^2O$. (H. Rose.)

Sulphydrate of Calcium, $Ca''H^2S^2$ or $Ca''S.H^2S$, is formed, together with the hydrate, when the monosulphide is repeatedly boiled with water. The best mode of preparing it is to pass sulphuretted hydrogen through hydrate or sulphide of calcium suspended in a considerable quantity of water, as long as it is absorbed, stirring well all the while. The solution thus formed has a sharp, bitter, hepatic taste, an alkaline reaction, and slight causticity. The compound cannot be separated from it in the solid state, even by evaporation in vacuo or in hydrogen gas, being resolved, as soon as crystallisation begins, into sulphydric acid which escapes, and sulphide of calcium which separates in silky prisms. If the solution be boiled down in a retort containing air, sulphydric acid escapes and oxysulphide of calcium is deposited (p. 715).

Sulphydrate of calcium may be used as a depilatory, and is recommended for this application by Böttger (Ann. Ch. Pharm. xxix. 79), in place of sulphide of arsenic. It may be prepared for the purpose by passing sulphuretted hydrogen into thin milk of lime till the mass acquires a bluish-grey colour (from admixed sulphide of iron). The paste thus formed, is laid, to the thickness of a line, on the surface from which the hair is to be removed, and scraped off after a minute or two with a blunt knife, the hair then coming away with it. If it could be produced cheaply enough, it might be used for removing the hair from hides in the tan-yard.

CALC-SINTER. *Stalactitic carbonate of lime.* It is found in pendulous conical rods or tubes, mammelated, massive, and in many imitative shapes. Fracture lamellar, or divergent fibrous. Lustre silky or pearly. Colours, white of various shades, yellow, brown; rarely green, passing into blue or red. Translucent, semi-hard, very brittle. Large stalactites are found in the grotto of Antiparos, the Woodman's cave in the Harz, the cave of Auxelle in France, in the cave of Castleton in Derbyshire, and Macalister cave in Skye. They are continually forming by the infiltration of carbonated lime water, through the crevices of the roofs of caverns. Solid masses of stalactite have been called oriental alabaster. The irregular masses on the bottoms of caves are called stalagmites. U.

CALCOFERRITE. A yellow laminar mineral, from Battenberg in Rhenish Bavaria, containing, according to Reissig, 34·01 per cent. P^2O^5; 24·34 Fe^2O^3, 2·96 Al^2O^3, 14·81 $Ca''O$, 2·65 $Mg''O$, and 20·56 water (= 99·27), a composition agreeing nearly with the formula $2(2Ca''O.P^2O^5).2Fe^2O^3.P^2O^5 + 12aq$. It exhibits perfect cleavage in one direction, and traces in two other directions, oblique to each other but perpendicular to the first, and is therefore probably orthorhombic. Specific gravity 2·52—2·53. Hardness = 2·5. Fuses readily before the blowpipe to a black, shining, Dissolves easily in hydrochloric acid. (Handw. d. Chem. ii. [2]

Calcareous Spar. Calcite.—The rhombohedral form of carbonate
primary form is an obtuse rhombohedron (*fig.* 116), in which the
cipal axis to that of the secondary axis as 0·8543 to 1, and the
inal edges is 105° 5′. Of this, there are numerous modifications,
many acute and obtuse rhombohedrons, and likewise scalenohedrons,
cleavable parallel to the faces of the primary rhombohedron. The
, seldom occurs as an unbroken crystal in pure calcspar, but is the
bitter-spar (Ca; Mg)CO^3. Most of the forms occur only in combination.
the most frequently occurring rhombohedrons are given in the fol-
of them being the *next acuter* rhombohedron with relation to the
xt *obtuser* with relation to that next below it. (See Crystallo-
al System.)

Principal axis.	Inclination of faces at terminal edges.	Inclination of faces at lateral edges.
0·2136	156° 2′	23° 58′
0·4271	134° 57′	45° 3′
0·8543	105° 5′	74° 55′
1·7086	78° 51′	101° 9′
3·4172	65° 50′	114° 10′

combinations of them, are shown in figures 115, 116, 117, 118, 119,
5 is one of the most common of the rhombohedrons, and is fre-

Fig. 116.

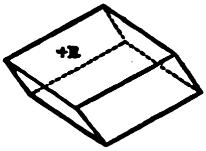


Fig. 117.

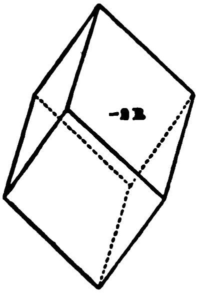


Fig. 119.

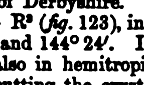


Fig. 120.

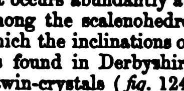
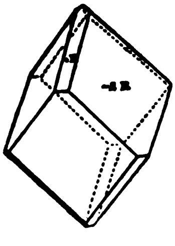


Fig. 121.



, but still more frequently in combination with the hexagonal prism,
seen in *fig.* 122. It occurs abundantly at Andreasberg in the Harz.
of Derbyshire. Among the scalenohedrons, is the variety called
R^3 (*fig.* 123), in which the inclinations of the faces in the terminal
and 144° 24′. It is found in Derbyshire and other localities. It
also in hemitropic twin-crystals (*fig.* 124), which may be supposed
cutting the crystal (*fig.* 123), in halves by a horizontal plane, and
halves through an angle of 180°.

vity of the purest crystals of calcspar is 2·721. Hardness = 3, being
een gypsum and fluorspar. Calcspar when pure is colourless, but
ous tints of yellow, green, red, brown, and even black, arising from
e vitreous. Translucent more or less, and when transparent, exhibits

in a remarkable degree, the double refraction of light. This property is b
the beautiful crystals obtained from Iceland, hence known as Iceland sp
crystals exhibit the ground-form R, being in fact merely fragments of large

Fig. 122.

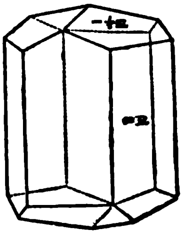


Fig. 123.

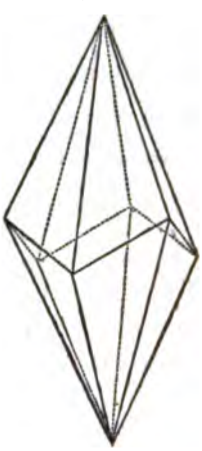
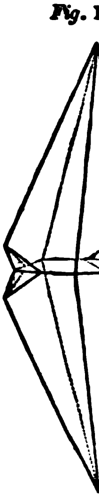


Fig. 1



Calcspar occurs in all parts of the world, and is one of the most
minerals. The lead-mines of Derbyshire and Cumberland, and of Andrea
Harz, are noted as affording the most beautiful crystals and the greate
form. [Respecting the circumstances under which carbonate of calcium
forms of calcspar and of arragonite, see ARRAGONITE, p. 358.]

CALCTUFF. An alluvial form of carbonate of calcium, probably de
calcareous springs. It has a yellowish-grey colour, a dull lustre intern
grained earthy fracture; is opaque, and usually marked with impressions
matter. Its density is nearly the same as that of water. It is soft and
broken.

CALCULUS, or **STONE.** The name generally given to all hard con
bony, formed in the bodies of animals. (See BEZOARS, BILIARY CALCU
CALCULI.)

CALDERITE. A mineral from Nepal, said by Söchting (Deu
Gesellschaft, ix. 4) to be a kind of garnet.

CALEDONITE. *Cupreous Sulphocarbonate of Lead*, from Leadh
and, consists, according to analyses by Brooke (Ed. Phil. J. iii. 117), and
(Phil. Mag. 1840, p. 402), of $3Pb''SO^4.2Pb''CO^3.Cu''CO^3$. It occurs in prism
of the trimetric system, with numerous secondary faces, sometimes large,
minute, and occasionally in branches diverging from a point. Specific gr
Hardness = 2·5—3. Colour verdigris- or bluish-green. Streak gre
Lustre resinous. Translucent. Fracture uneven. Rather brittle. It
duced before the blowpipe, and dissolves partially in nitric acid, with
sulphate of lead.

CALENDULIN. A mucilaginous substance extracted from the leave
of the common marigold, *Calendula officinalis*. (Geiger, *Diss. de Cal. off.*,
1848.)

CALICO-PRINTING. The art of dyeing cloth (chiefly cotton
topically; that is, impressing figures in one or more colours on certain
cloth, while the rest of the surface is left in its original state. (See *Ure'*
of Arts, Manufactures, and Mines, i. 491.)

CALIFORNIN. A bitter principle extracted from *Chica Californica*.
Buchn. Repert. xxxii. 20.)

CALISAYA BARK. See CINCHONA BARK.—**CALLAIS.** See T

CALLUNA VULGARIS. An ericaceous plant, commonly calle
contains, according to Rochleder, a peculiar tannic acid; the leaves a

latile oil, an acid, probably citric acid, and a small quantity of
the air-dried plant yield, according to Sprengel, 1·95 ash (I.)
plant collected at the end of August, 5·55 per cent. water, and
ded 6·35 per cent. ash (II.) Nutzinger found in the air-dried
or-land, 2·87 per cent. ash (III.); and Thielau found in the flower-
the lias sand-stone, 3·32 per cent. ash (IV.) The ash contained

CaO	MgO	Al^2O^3	Fe^2O^3	Mn^2O^3	Cl	SO^3	P^2O^5	SiO^2
26·5	8·4	2·3	2·7	4·6	4·9	5·2	0·6	29·7
12·0	6·7	—	4·9	4·1	—	1·7	10·9	48·1
33·5	8·0	0·8	2·0	3·8	1·8	1·4	4·0	32·7
15·5	6·6	0·5	1·5	4·7	4·1	1·0	5·3	30·9

IC ACID. $C^{14}H^{14}O^9$ or $C^{14}H^7C^9$ (Rochleder, Ann. Ch. Pharm.
annic acid of *Calluna vulgaris*. To obtain it, the alcoholic extract
the plant (without the root) is mixed with water; the liquid filtered
tate of fat, chlorophyll, &c., is precipitated with acetate of lead; the
eated with very dilute acetic acid, in which it is but partially soluble;
ith excess of sub-acetate of lead; the resulting yellow precipitate
uretted hydrogen; and the filtered liquid evaporated on a chloride
atmosphere of carbonic anhydride. Callutannic acid then remains
er-coloured mass. This acid does not form any definite salts with
aline-earth-metals or silver: for its solutions in alkalis or alkaline
rb oxygen from the air, and oxide of silver is immediately
leder has obtained two lead-salts to which he assigns the formula
and $8PbO.2H^2O.3C^{14}H^{12}O^8$, and a stannic salt said to contain
O^8.

nay be used to dye wool. The aqueous solution mixed with stannic
rops of hydrochloric acid, and heated to the boiling point, imparts
with alum, a sulphur-yellow to chrome-yellow colour, according to
olution and the time of immersion.

HIN. $C^{14}H^{10}O^7$.—A yellow flocculent substance obtained by
cid with dilute mineral acids. It is sparingly soluble in cold
water and in alcohol. It dissolves also in alkaline liquids, but
absorbs oxygen, and is then precipitated by dilute acids in red-
chleder.)

Iemichloride of mercury or mercurous chloride. See MERCURY.

M RESIN. *Maynas resin*, $C^{14}H^{18}O^4$.—A resin from Maynas
btained from *Calophyllum Caloba* or *C. longifolium*. It has the
sin, dissolves in alcohol, ether, and oils, both fixed and volatile,
boiling alcohol in small transparent colourless prisms of specific
elts at 105° C., but does not resolidify till cooled to 90°. It is
distillation; dissolves with red-brown colour in sulphuric acid,
naltered by water; and when heated with nitric acid of specific
to yield butyric and oxalic acids, together with another acid which
calcium-salts. With chromic acid, it is said to yield carbonic
t dissolves in alkalis. (Levy, Compt. rend. xviii. 242.)

ER. An instrument for the estimation of latent heat, specific
stion, &c. (See HEAT.)

OR. A voltaic arrangement consisting of one pair or a few pairs
used chiefly for producing considerable heat effects. (See ELEC-

ARYTE. Shepard's name for a variety of heavy spar from
rk, mixed with carbonate of strontium and calcium. (Sill. Am. J.

E. A mineral from Haddam and Mittletown in Connecticut,
re prisms of specific gravity 4·34, hardness 6·5. Probably an
epard, Sill. Am. J. [2] xii. 210.)

RESIN. A resin from *Morus indica*.

APONICA. The leaves contain tannin, which is sparingly
tin, abundantly by lead and iron salts: they do not contain theine.

WOOD. See LOGWOOD.

ACID and **CAMPHAMIDE.** See CAMPHORAMIC ACID and

CAMPHENE. This term is used in various ways; sometimes as a ge
for the hydrocarbons isomeric or polymeric with oil of turpentine, someti
name of the radicle of camphor ($C^{10}H^{16}$) and its allied compounds. By
Berthelot, it has been applied especially to the hydrocarbon, also contain
obtained by the action of alkalis on hydrochlorate of turpentine-oil. Laur
the same appellation to the radicle of oil of cloves, eugenin, &c.

Chlorinated and brominated derivatives of camphene, *e. g.* $C^{10}H^{14}Cl^2$ an
are obtained by the action of chlorine or bromine on oil turpentine and
A *monochlorocamphene*, $C^{10}H^{15}Cl$, and a *dichloride of camphene*, $C^{10}H^{16}Cl^2$, a
by the action of pentachloride of phosphorus on camphor (see p. 728).

CAMPHENES or *Terebenes.* The generic name for the volatile oi
carbons $C^{5n}H^{8n}$, isomeric or polymeric with oil of turpentine. Most of them
and consist of $C^{10}H^{16}$, *e. g.* oil of turpentine, oil of lemons, oil of juniper
&c.; some, as colophene, appear to consist of $C^{20}H^{32}$.

Many camphenes exist ready formed in plants, as the oils of juniper,
turpentine; they are often contained in the natural oils associated with
compounds, and may be separated therefrom by fractional distillation, as c
oil of caraway, borneene or valerene from oil of valerian, &c. Many a
from oxygenated compounds containing $C^{5n}H^{8n}$ + water, by the action of
anhydride (*e. g.* borneene from borneol, cinæbene from wormseed-oil, &c.)
formed from oxygenated oils by the action of hydrate of potassium (oil o
others); some by dry distillation, as oil of amber, caoutchin, &c.

All the camphenes are liquid at ordinary temperatures (except Berthelot'
which is a solid melting at 46° C.); they have for the most part a densi
0·9 (oil of parsley is the only one heavier than water, specific gravity =
and boil between 155° and 165° C.; their observed vapour-density varies
4·8, the formula $C^{10}H^{16}$ calculated for 2 vol. giving a thoretical density of
only boil at higher points, viz. oil of copaiba at 250° C.; petrolene at
phene at about 310°; cinæphene at nearly 320°, metaterebene about
observed vapour density of carvene is 5·1, of tolene 5·7, of petrolene 9·4,
11·1; the formula $C^{20}H^{32}$ calculated for 2 vol. requires 9·4.

Camphenes are distinguished one from the other by their odours, which
oil of lemon, are very fragrant, in others, as in oil of copaiba, extremely d
also by their action on polarised light. All natural camphenes possess
rotatory power in a greater or less degree, some turning the plane of polaris
right, others to the left; but even in the same oil, the strength and dire
rotatory power vary according to the temperature and other circumstances.

Camphenes readily absorb *oxygen* and convert it into ozone. *Iodine* f
part decomposes them readily and with evolution of heat, sometimes even
explosion, the iodine taking the place of a portion of the hydrogen; t
serves to detect the admixture of camphenes, oil of turpentine, for example
volatile oils. *Chlorine* and *bromine* act in a similar manner.

Camphenes treated with *bromine* and *water* are easily converted into
oils (Gr. Williams, Phil. Mag. [4] v. 536). According to Chautard (C
xxxiii. 671; xxxiv. 485), camphenes distilled with *water* and *bromide* or
lime, yield, amongst other products, bromoform or chloroform.

Most camphenes unite with *hydrochloric acid*, forming either liquid or
compounds, frequently having the composition $C^{10}H^{16}.HCl$ or $C^{10}H^{16}.2$
compounds, called artificial camphors, have the same rotatory power as t
which they are produced. Similar compounds are formed with *hydr*
hydriodic acid.

Natural camphenes treated with *acids*, especially with *strong sulphuric*
rally undergo an alteration of molecular arrangement without change of ch
stitution, the odour being for the most part greatly altered, sometim
density and boiling point; but the most characteristic alteration is the los
rotatory power. A camphene often yields several isomeric modifications b
with different acids, or by repeated treatment with the same acid. The new
thus produced are called camphenes of the second order, or somet
pherenes. Another class, called camphenes of the third order, or
camphilenes, are obtained by the action of lime or baryta at high t
on the hydrochlorates of other camphenes; these are also optically in
generally differ greatly in odour from the original camphenes, but often ex
the same specific gravity and boiling point. The camphenes of the secon
orders are decomposed by chlorine, bromine, and iodine, and form liquid or
compounds with hydrochloric, hydrobromic, and hydriodic acids.

The camphenes are a very numerous class of bodies; the principal of the

ergamot
e

in
ne
oil of cloves
opaiba
lemi

Gaultherilene
Oil of gomart
Oil of hops
Oil of juniper
Oil of lemon
Oil of orange
Oil of parsley

Oil of pepper
Petrolene
Oil of savin
Thymene
Tolene
Oil of turpentine

ng to specific gravity, boiling point, vapour-density, and rotatory
ral oils. (Handw. d. Chem. ii. [2] 691; Gm. xiv. 271—322 and

ES. Camphenes of the second order (p. 724).

or **CAMPHERILE.** A name applied by Laurent to the im-
(*q. v.*) which he obtained from camphorate of calcium.

CID. $C^{10}H^{16}O^2$?—A product obtained, together with borneol, by
ith alcoholic soda-solution in sealed tubes to 170°—190° C.

$$\underset{\text{Camphor.}}{2C^{10}H^{16}O} + H^2O = \underset{\text{Borneol.}}{C^{10}H^{18}O} + \underset{\text{Camphic acid.}}{C^{10}H^{16}O^2}.$$

product with sulphuric acid, dissolving out the camphate of sodium
rating and again adding sulphuric acid, the camphic acid separates
loured mass, heavier than water, sparingly soluble therein, easily
It is decomposed by nitric acid. The potassium and sodium-salts
in strong alkaline leys; they precipitate the salts of copper, iron,
nc, not those of the alkaline-earth metals; all the precipitates are
uantity of water. (Berthelot, Ann. Ch. Phys. [3] lvi. 94.)

. This term was applied by Laurent to nuclei in which the com-
s replaced by oxygen.

E. Deville's name for the camphene obtained by treating hydro-
ne-oil with lime. Camphenes of the third order (p. 724) are some-
hilenes.

E. See CAMPHORIMIDE.

$C^{10}H^{18}$ or C^9H^{16}? (Claus, J. pr. Chem. xxv. 262; Gm. xiv. 448.)
r with campho-creosote, colophene, and campho-resin, by triturating
qual weight of iodine, and distilling. A black mass then remains
-resin, and the distillate separates on standing, into a watery layer
ic acid, and an upper oily layer containing camphin, campho-creo-
e. To obtain the camphin, the mixture is agitated with mercury,
then rectified *per se*, and the most volatile portion shaken up with
peatedly rectified over potash-lime to remove iodine; it may also be
traces of iodine by setting it aside with potassium and rectifying.
in colourless oil of specific gravity 0·827 at 25° C., and boiling at
pressure of 28 inches. It has a pleasant odour, like that of oil of mace,
e turpentine. It gave by analysis 86·06 per cent. C and 12·79 H;
requires 86·96 C and 13·04 H, while C^9H^{16} requires 87·10 C and
lt regarded it as impure cymene, $C^{10}H^{14}$ (89·5 C and 10·5 H).
with a bright but very smoky flame. It dissolves in *alcohol*, *ether*,
nd *rock-oil*; but not in water, weak alcohol, potash, or dilute acids,
hydrochloric acid. It absorbs a small quantity of *hydrochloric acid*
ightly attacked by *sulphuric acid*. *Nitric acid*, with aid of heat,
yellow nitrogenised oil, smelling like cinnamon, or by prolonged
d oil soluble in potash. *Pentachloride of antimony* converts it into

dily decomposed by *chlorine* and *bromine*, yielding *substitution-pro-*
rocamphins are transparent, colourless, oily bodies, which, when
olic potash, yield chloride of potassium and a chlorinated oil having
r. Claus obtained two compounds, which he regarded as $C^9H^{13}Cl^3$

. This term is applied in commerce to purified oil of turpentine,
lly distilling the oil over quick lime, sometimes also rectifying it
of lime; in this manner it is obtained quite free from resin. In
is treated with sulphuric acid previous to rectification. This puri-
is much used for burning in lamps, giving a very brilliant light.
y apt to smoke, and must therefore be burnt in lamps of peculiar
very strong draught. A solution of camphine in three times its

volume of alcohol of specific gravity 0·820, sometimes with addition of a little ether to ensure more complete solution, is also used as an illuminating material, and may be burned in ordinary lamps with argand burners.

CAMPHOCREOSOTE. A product of the decomposition of camphor by iodine at high temperatures; according to Schweizer, it is probably identical with carvacrol (*q. v.*)

CAMPHOGEN. Dumas' name for the hydrocarbon $C^{10}H^{14}$, obtained from camphor by the action of phosphoric anhydride; it is identical with cymene (*q. v.*)

CAMPHOL. This name was applied by Gerhardt to the camphor of the Lauraceæ; but Berthelot has recently applied it (Ann. Ch. Phys. [3] lvi. 78), to Borneol or Borneo-camphor, which he regards as the alcohol of a series in which common camphor is the aldehyde, thus:

Ethyl-series.		Camphyl-series.	
Ethyl-alcohol,	C^2H^6O	Camphol,	$C^{10}H^{18}O$
Aldehyde,	C^2H^4O	Camphor,	$C^{10}H^{16}O$
Acetic acid,	$C^2H^4O^2$	Camphic acid,	$C^{10}H^{16}O^2$
Chloride of ethyl,	C^2H^5Cl	Chloride of camphyl,	$C^{10}H^{17}Cl$
Ethylene,	C^2H^4	Camphene,	$C^{10}H^{16}$

Camphol is produced by treating camphor with alcoholic potash (p. 626), just as benzylic alcohol is produced from benzoic aldehyde (p. 578). It is also formed by distilling amber with ¼ of its weight of potash and a large quantity of water.

From later experiments by Berthelot and Buignet (Compt. rend. l. 606), it appears that the several bodies to which the name camphol has been applied, are isomeric but not identical, being especially distinguished by their different rotatory power, which in camphol from common camphor = +44·9°; in natural camphor or borneol, = +33·4°; in camphol from amber = + 4·5°; while in lævo-rotatory borneol, or camphol obtained from madder-camphor (p. 626), it is —33·4°.

According to Berthelot, camphol heated with acids unites with them, like all alcohols, with elimination of water. The resulting compound ethers may be purified by removing the excess of acid with slaked lime and ether, and distilling off the excess of camphol by prolonged heating at 150°C. They are colourless, neutral, soluble in alcohol and ether; some are liquids, others crystalline; the latter melt at a lower temperature than camphol. Alkalis decompose them into acid and camphol, the latter exhibiting its original properties. *Benzoate of camphol*, $C^{17}H^{22}O^2 = C^7H^5(C^{10}H^{17})O^2$, is a neutral, colourless, inodorous oil.—*Stearate of camphol*, $C^{28}H^{52}O^2 = C^{18}H^{35}(C^{10}H^{17})O^2$, is colourless, inodorous, viscid, solidifying after a while in a crystalline mass.—*Chloride of camphyl*, $C^{10}H^{17}Cl$, obtained by heating camphol (borneol) with strong hydrochloric acid to 100° C. in a sealed tube for 8 or 10 hours, and purified by washing with dilute potash and crystallisation from alcohol, has the aspect, odour, and empirical composition of hydrochlorate of turpentine-oil or artificial camphor ($C^{10}H^{16}.HCl$), but turns the plane of polarisation to the left, somewhat less strongly than borneol. Heated to 180° C. with alcoholic soda-solution, it yields chloride of sodium and borneol. By this and by its rotatory power, it is sufficiently distinguished from hydrochlorate of turpentine-oil. (Handw. d. Chem. 2te Aufl. ii. [2] 695.)

CAMPHOLENE. C^9H^{16}. A liquid hydrocarbon obtained by distilling campholic acid with phosphoric anhydride. Vapour-density 4·353. (Delalande.)

CAMPHOLIC ACID. *Bornenic acid.* $C^{10}H^{18}O^2 = C^{10}H^{17}O.H.O.$—Produced by the action of hydrate of potassium on camphor. The quantity found under the ordinary atmospheric pressure is but small: but if the camphor be enclosed, together with potash-lime, in a sealed combustion tube of the ordinary dimensions, and its vapour made to pass several times over the heated potash-lime, about 5 or 6 grammes of purified acid may be obtained from each tube. To isolate the acid, the contents of the tube are digested in water, and the solution decomposed by a stronger acid. The campholic acid is then deposited as a crystalline mass, which may be purified by distillation. It is white, and crystallises well from a mixture of alcohol and ether; melts at 50° C.; boils without alteration towards 250°. Insoluble in water, but imparts to it an aromatic odour. Vapour-density 6·058. Distilled with phosphoric anhydride, it yields campholene, carbonic oxide being probably evolved at the same time:

$$C^{10}H^{18}O^2 = CO + H^2O + C^9H^{16}.$$

It is monobasic. The *calcium-salt*, $Ca''(C^{10}H^{17}O^2)^2$, is a snow-white crystalline powder obtained by pouring chloride of calcium into a nearly boiling solution of the acid in excess of ammonia. By dry distillation, it yields an oily body called *campholone*, $C^{19}H^{34}O$:

$$Ca''(C^{10}H^{17}O^2)^2 = CaCO^3 + C^{19}H^{34}O.$$

ver, obtained by decomposing the neutral ammonium-salt with nitrate
rdy flakes. (Delalande, Ann. Ch. Phys. [3] i. 120.)

E. Syn. of CYMENE.

ETHYLIC ACID. Camphorate of methyl and hydrogen. (See
p. 733.)

$C^{10}H^{16}O$. (Gm. xiv. 358; Gerh. iii. 621).—A crystalline substance
Laurus camphora and other plants in which it exists ready formed.
nodifications of it, identical in composition and chemical properties,
heir action on polarised light, viz. *dextro-camphor*, which turns the
ion to the right, *lævo-camphor*, which turns it to the left, and *inactive*
as no action on polarised light.

mphor. *Laurel* or *common camphor*. This variety exists in the wood
ral trees of the Lauraceous order, chiefly in the *Laurus camphora*, a
n Japan, Java, Sumatra, and Borneo. The process of extraction is
China and Japan, the wood, sawn into billets, is distilled with water
d with an earthen capital lined with rice-straw, on which the crystals
deposited, being carried up by the aqueous vapour. The crude
tained is exported to Europe, where it is purified by sublimation. In
neo, the wood is split with wedges, and the camphor, which is found
es in tears and crystals, is extracted; a single tree sometimes yields
ty pounds.

or is also produced artificially by the action of nitric acid on borneol
orneo, $C^{10}H^{18}O$ (pp. 626, 726).

allises by sublimation, or by slow deposition from an alcoholic solution,
segments of octahedrons. It is white and semi-transparent, like ice,
ctile, and not easily reduced to powder without the aid of a little
s at 175° C. and boils at 204° C. evaporating completely away without
pecific gravity varies from 0·986 to 0·996. Vapour-density = 5·317
ter dissolves $\frac{1}{1000}$ pt. of camphor, and thereby acquires its peculiar
When small bits of camphor are thrown into water in a broad basin,
move about with more or less velocity, in proportion to their small-
ations are attributed to the force exerted by the vapours rapidly ex-
amphor on the surface of the water; but the explanation is not very
a pin-point slightly smeared with oil be dipped into the water, all
instantly, and the particles of camphor are repelled from the pin-spot
g film of oil. The dispersion of the camphor-vapour is made very
epulsion of the water on a moistened saucer from the points on which
ance are laid.

or is soluble in alcohol, ether, acetone, acetic acid, wood-spirit, sul-
and oils. 100 pts. of alcohol of specific gravity 0·806 dissolve 120 pts.
is thrown down almost entirely in flocks by the addition of water.
nts in a remarkable degree the solubility of corrosive sublimate in

tatory power of the alcoholic solution of camphor, is 47·4 for a length
s. According to Arndtsen (Ann. Ch. Phys. [2] liv. 403), it increases
ibility of the rays much more quickly than is observed in any other
l camphor does not exhibit any rotatory power.

Camphor, when set on fire in the *air*, burns with a smoky flame, pro-
d carbonic acid. Spongy *platinum*, or a coil of fine platinum wire laid
gins to glow when the camphor is set on fire, and continues glowing
s blown out. Camphor is set on fire by *chlorochromic acid*.—2. By
g with *nitric acid* or *permanganate of potassium*, it is converted into
p. 730).—3. Heated with *strong sulphuric acid* to 100° C. for 12—13
erted into camphrene, $C^{9}H^{12}O$, with evolution of sulphurous anhydride
f charcoal (Chautard, Compt. rend. xliv. 66). According to Dela-
839, p. 399), camphor heated with excess of strong sulphuric acid, is
volatile oil, which has the chemical properties and composition of
r, but less rotatory power, and when heated with potash to nearly
rted into a solid camphor, whose rotatory power is intermediate be-
mmon camphor and that of the oily camphor. Gerhardt supposed that
l by Delalande was cymene; according to Chautard, it is camphrene
hor.—4. Camphor-vapour passed through a *red-hot glass* or *porcelain*
ombustible gas and an oil soluble in alcohol (Saussure).—5. When
mphor is passed over *red-hot iron*, an oily liquid is produced, contain-
ne and a hydrocarbon boiling at 140° C. and having the composition
'Arcet, Ann. Ch. Phys. [2] lxvi. 110).—6. Camphor distilled with

2 pts. *alumina* or *clay*, is resolved into carbonic anhydride, carburetted
empyreumatic oil, and a residue of charcoal.—7. Distilled with *phosphoric*
it is resolved into water and **cymene**, $C^{10}H^{14}$ (Delalande, Ann. Ch. Phys.
Heated with concentrated phosphoric acid, it volatilises for the most part
posed. It is also resolved into water and cymene by distillation with *chlori*
—8. Camphor-vapour passed over *red-hot lime*, yields **camphrone**, $C^{30}H$
liquid boiling at 75° C. At a very bright red heat, this product is resolved int
oxide, carburetted hydrogen, and naphthalene (Frémy, Ann. Ch. Phys.
9. When the vapour is passed over heated *potash-lime*, under pressure, ca
of potassium, $C^{10}H^{17}KO^2$ is produced (Delalande, p. 726).—10. Camp
to 180°—200° C. with *alcoholic potash* or *soda*, is converted into **borneol**
lot, pp. 626, 726).—11. When camphor is triturated with *iodine*, and the
distilled, a dark-coloured oily liquid passes over, containing **camphin**,
creosote, and **colophene**, and a blackish residue is left, containing **cam**
(Clauss, p. 725).—12. *Bromine* unites with camphor, forming an instable **b**
camphor, $C^{10}H^{16}O.Br$, which is crystalline, and is decomposed by heat, by c
air, and by the action of ammonia.—13. *Chlorine* exerts but little action o
even in sunshine.—14. With *pentachloride of phosphorus*, camphor yields o
of phosphorus, and a crystalline substance, $C^{10}H^{16}Cl^2$, having the aspect o
camphor (hydrochlorate of turpentine-oil). It remains dissolved in the o
and may be precipitated by water (Gerhardt):

$$C^{10}H^{16}O + PCl^5 = POCl^3 + C^{10}H^{16}Cl^2.$$

This compound yields by repeated dry distillation, a chlorinated oil co
$C^{10}H^{15}Cl$. (Gerhardt.)

According to Pfaundler (Ann. Ch. Pharm. cxv. 29), 1 at. camphor heate
110° C. with 1 at. PCl^5, yields hydrochloric acid, oxychloride of phosphorus,
rocamphene, $C^{10}H^{15}Cl$, which is a white, soft, crystalline substance, having
of camphor. Its index of refraction is 1·49327. It is insoluble in water, bu
in 3·5 pts. of 87 per cent. alcohol at 14° C., forming an optically inactive solu
crystals volatilise rather quickly at ordinary temperatures, melt at about 6
then sublime, decomposing at higher temperatures. With 2 at. pentachlori
phorus to 1 at. camphor, **chloride of camphene**, $C^{10}H^{16}Cl^2$, is obtained
crystals, resembling the preceding in aspect and in odour, but softer, and
index of refraction = 1·50553. It dissolves in 4·95 pts. of 87 per cent.
14° C., forming a solution possessing lævo-rotatory power. The crystals
rather quickly at ordinary temperatures, and melt with partial sublimation
—15. If *chlorine* be passed through the solution of camphor in *trichlorid*
phorus, various substitution-products are formed, according to the time for
action of the chlorine is continued. ***Tetrachlorocamphor***, $C^{10}H^{12}Cl^4O^2$,
isolated, though not quite pure. If the action be continued for a long time, a
by heat, a colourless product is at length obtained, having the aspect of
and consisting of ***sexchloro-camphor***, $C^{10}H^{10}Cl^6O$ (Claus, J. pr. Chem.
—16. When camphor is heated with *mercuric chloride*, hydrochloric acid
together with an odour of turpentine, and a carbonaceous mass containi
remains.—17. *Pentachloride of antimony* attacks camphor strongly, giving
chloric acid, and forming a resinous substance.—18. *Hydrochloric acid gas* i
by camphor in quantities varying according to pressure and temperature, as
the following table, which gives the quantity of the gas (HCl) absorbed b
camphor, at the temperature *t* and barometric pressure *b*:

t	24°	20°	18·5°	18·5°	13°	9°	7°	7°	3°
b	747	740	735	744	320	288	270	740	232
HCl	19·0	20·0	20·4	20·5	15·3	15·8	16·3	240	17·0

At a certain low pressure, camphor no longer absorbs hydrochloric acid
pressure varies with the temperature, being 220 mm. at 12°; 340 mm.
300 mm, at 20°; and 423 mm. at 24° (Bineau, Ann. Ch. Phys. [3] xxi
19. *Sulphurous anhydride* is quickly absorbed by camphor, forming a colourl
which is heavier than water, dissolves iodine and camphor, and when satu
camphor, contains 4 pts. camphor to 1 pt. SO^2. It gives off sulphurous anhy
at ordinary temperatures. The quantities absorbed by 100 pts. camphor
pressures and temperatures, are given in the following tables (Bineau, *loc.*

t	24°	24°	15·5°	15·5°	12·5°	12·5°	2°	8°	4°	4°	2°
b	624	745	355	744	529	727	304	682	490	720	649
SO^2	25·5	35·4	28·0	47·6	37·3	50·5	33·0	57·4	46·0	73·6	48·4

sure, 100 pts. camphor absorb of SO^2:

20°	15·5°	14°	12·5°	10°	8°	4° C.
37·7	44·3	46·8	48·9	54·0	58·6	70·5

orbs the vapour of *peroxide of nitrogen* (or nitric oxide in presence
liquid which is decomposed by water, dissolves camphor, and
erewith at 18° C., contains 100 camphor to 26—27 peroxide of
u.)

hor.—When the essential oil of feverfew (*Pyrethrum parthenium*)
led, and the portion which distils between 200° and 220° C. is col-
osits on cooling a large quantity of camphor, similar in all respects
r, excepting in its optical rotatory power, which is equal and oppo-
47·4 for a length of 100 millimetres. The camphor treated with
evo-camphoric acid. (Dessaignes and Chautard, J. Pharm. [3]
rd, Compt. rend. xxxvii. 166.)

amphor.—According to Proust, the essential oils of several labiate
y, marjoram, lavender, and sage, often deposit a substance like
r camphor has the same composition as laurel camphor, but is with-
longed light. (Dumas, Ann. Ch. Phys. xiii. 275; Biot, Compt.

g camphor but of undetermined modification, have been obtained
tric acid on the essential oils of tansy, semen-contra, valerian, and
n amber is treated with nitric acid, it yields a distillate containing
ay be extracted by saturating with carbonate of potassium and
r.

ARTIFICIAL. Syn. with HYDROCHLORATE OF TURPENTINE-OIL.

OF BORNEO. See BORNEOL.

OIL OF. When the branches of the camphor-tree (*Laurus cam-*
ed with water, a volatile oil passes over together with camphor.
colourless, has a strong odour of camphor and considerable dextro-
d is resolved by fractional distillation into an oil boiling at 180° C.
ng at 205°; the latter appears to be essentially the same as common
l boiling at 180° is very much like oil of lemon, possesses strong
wer, and forms with hydrochloric acid a crystalline compound, which
gives by analysis 57·34 per cent. C, 8·6 H, and 33·83 Cl, agreeing
$C^{10}H^{16}.2HCl$. (Lallemand, Ann. Ch. Phys. lvii. 404.)

yabalanops Camphora, from which borneol is obtained, likewise yields
ater, a camphor oil, separable by fractional distillation into two vola-
he composition $C^{10}H^{16}$, one boiling between 180° and 190° C., the
0°, and a resin, $C^{30}H^{46}O^2$ (?), which melts at a temperature a little
emand). It is remarkable that the oil of Dryabalanops examined
not contain borneol, and that even the most volatile portion of it
t much higher than that of borneene (p. 626). The subject requires
on. (See DRYABALANOPS.)

MIC ACID. $C^{10}H^{17}NO^3 = \left.\begin{matrix} N.H^2.(C^{10}H^{14}O^2)'' \\ H \end{matrix}\right\} O.$ (Laurent,
5, p. 147.)—Derived from acid camphorate of ammonium by elimi-
ter:

$$C^{10}H^{15}(NH^4)O^2 - H^2O = C^{10}H^{17}NO^3.$$

alt of this acid is produced by the action of ammonia on a boiling
of camphoric anhydride ($C^{10}H^{14}O^3 + 2NH^3 = C^{10}H^{16}(NH^4)NO^3$), and
olution of this salt with hydrochloric acid and evaporating, campho-
sited in crystals, which may be purified by solution in dilute alcohol
evaporation. It is then obtained in splendid crystals, belonging to
tem, $\infty\breve{P}\infty \,.\, \infty\bar{P}\infty \,.\, \breve{P}\infty$, with ∞P and P subordinate. Inclination
$: P\infty = 114^\circ\, 30'$; $\breve{P}\infty : \infty\breve{P}\infty = 122^\circ\, 45'$; $\breve{P}\infty : P = 155^\circ$; $\infty\breve{P}\infty :$
It is colourless, moderately soluble in hot water, less in cold; more
A small quantity melted on a plate of glass, partly crystallises in
rest solidifies slowly into a transparent vitreous mass.

onobasic. Its *ammonium-salt*, $C^{10}H^{16}(NH^4)NO^3 + H^2O$, crystallises
ly acid, bitter, transient taste, and melts at 100° C. It differs from
ate of ammonium, with which, in the hydrated state, it agrees in
ot precipitating the salts of lead, copper, or silver. The *lead-salt*,
is deposited in small crystals, on mixing the concentrated boiling alco-

holic solutions of camphoramate of ammonium and acetate of lead, the former
and leaving the liquid to cool. The *silver-salt*, $C^{10}H^{16}AgNO^{3}$, is obtained a
parent jelly, composed of minute crystals, on mixing the boiling concentrated
of camphoramate of ammonium and nitrate of silver, and leaving the liquid

CAMPHORANILIC ACID. See Phenyl-Camphoramic Acid.

CAMPHORAMIDE. $C^{10}H^{18}N^{2}O^{2} = N^{2}.H^{4}.(C^{10}H^{14}O^{2})''$.—When a c
ammonia-gas is passed into the middle of a solution of camphoric anhydrid
lute alcohol, the liquid becomes heated, and yields by evaporation a syrupy
soluble in water, which is probably camphoramide. It is not decomposed i
by hydrochloric acid; but when treated with potash, it gives off ammonia,
camphorate of potassium. (Laurent, Rev. scient. x. 123.)

CAMPHORESIN. The name given by Claus to the non-volatile prod
action of iodine on camphor (p. 728).

CAMPHORIC ACID. $C^{10}H^{16}O^{4} = C^{10}H^{14}O^{2}.H^{2}.O^{2}$. (Gm. xiv. 455;
700.)—There are three modifications of this acid, corresponding to those of
viz. *dextro-rotatory*, *lævo-rotatory*, and *inactive*.

Dextro-camphoric or *ordinary Camphoric acid.*—This acid was dis
Kosegarten (*Diss. de camphora et partibus quæ eam constituant*, Göttingen,
particularly studied by Laurent (Ann. Ch. Phys. lxiii. 207; Compt. Cl
p. 141), Malaguti (Ann. Ch. Phys. lxiv. 151), and Liebig (Ann. Ch. Ph
50). To prepare it, common camphor is heated in a retort with ten times
of strong nitric acid, the liquid being cohobated several times, and the aci
On evaporating and cooling the residual liquid, the camphoric acid crystallise
may be purified by dissolving it in carbonate of potassium, precipitating
acid, and recrystallising several times.

Camphoric acid forms colourless transparent scales or needles, which melt
and taste sour and bitter at the same time. It is sparingly soluble in cold w
readily in boiling water; easily also in alcohol, ether, and fatty oils. Ac
Brandes, it requires for solution, 88·8 pts. of water at 12·5° C., and 8·6 pts.
Molecular rotatory power of the solution $[\alpha] = +\ 38{\cdot}875$; this power dimin
siderably on saturating the acid with an alkali.

It gives an abundant precipitate with neutral acetate of lead. By dry
it is resolved into water and camphoric anhydride, leaving only a small film o
It dissolves without alteration in strong nitric and sulphuric acid.

β. *Lævo-camphoric Acid.*—Obtained by the action of nitric acid on th
of feverfew (p. 729), has the same composition and chemical properties as d
phoric acid, and rotates the plane of polarisation, by exactly the same amo
left. (Chautard, Compt. rend. xxxvii. 166.)

γ. *Inactive Camphoric Acid*, or *Paracamphoric Acid*, is produced by mi
weights of dextro- and lævo-camphoric acid. It agrees with ordinary camp
in most of its properties, but has no action on polarised light. (Chautar

Camphorates.—Camphoric acid is dibasic, the formula of a neutral c
being $C^{10}H^{14}M^{2}O^{4}$. The camphorates are odourless, and have a slightly bi
Most of them are sparingly soluble in water. They are decomposed by
hydrochloric, and nitric acid.

Camphorates of Ammonium.—The neutral salt, $C^{10}H^{14}(NH^{4})^{2}O^{4}$, is ob
passing a current of dry ammonia-gas over camphoric acid, and exposing t
to a current of dry air. It is very soluble in water, and has a slight acid re
no decided taste. An *acid ammonium-salt* is obtained in small prisms, mel
100° C. by throwing crystals of acid carbonate of ammonium into a boiling
camphoric acid. When dried at 100° in a current of air, they lose 19 p
water. They contain, according to Malaguti, 53·57 per cent. carbon, 8·97
and 8·5 nitrogen, whence he deduces the formula $3C^{10}H^{16}O^{4}.4NH^{3} + 9H^{2}O$,
say, a compound of 1 at. neutral camphorate and 2 at. acid camphorate of a
but, according to Gerhardt, the salt is an *acid camphorate*, $C^{10}H^{15}(NH^{4})O$ +
formula of which requires 55·3 C, 8·7 H, 6·6 N, and 19·9 per cent. water.

Camphorate of Potassium. $C^{10}H^{14}K^{2}O^{4}$.—Crystallises in large nacreous s
prepared with hydrated camphoric acid, and in small delicate needles when p
dissolving camphoric anhydride in potash. According to Bucholz and
Lagrange, it is but sparingly soluble in water, whereas Brandes states that
deliquescent, and dissolves in a very small quantity of water (probably the
soluble salt was an acid salt). Camphorate of sodium forms limpid, confuse
efflorescent crystals, soluble in 200 pts. of cold and 8 pts. of boiling wate
alcohol.

The *barium-salt* forms laminæ or needles soluble in 600 pts. of boiling
cording to Brandes, in 1·8 pts. water at 19·9° C.

-*salt* forms colourless laminæ much more soluble than the barium-

-The neutral salt forms a non-crystalline mass, neutral to test-paper,
n cold water, soluble in 200 pts. of boiling water, insoluble in alcohol,
per cent. water of crystallisation. It falls to powder in contact with
ating carbonate of calcium with camphoric acid, a salt is obtained
eaction, and crystallising in rhomboïdal prisms, containing 37·5 per
soluble in 5 pts. of cold water (Bucholz, Brandes). Neutral cam-
n yields, by dry distillation, carbonate of calcium and camphorone:

$$C^{10}H^{14}Ca''O^4 = CO^3Ca'' + C^9H^{14}O.$$

Copper, $C^{10}H^{14}Cu''O^4$ (at 100°), is obtained by double decomposition
recipitate, nearly insoluble in water. It forms a crystallisable com-
onia.

Manganese is very soluble in water. Manganous salts are not pre-
ine camphorates.

phorate is a white precipitate, nearly insoluble in water.

Silver is a white fusible precipitate, which becomes coloured by ex-

C ANHYDRIDE. *Anhydrous camphoric acid.* $C^{10}H^{14}O^2.O$
range (1799), Ann. Chim. xxiii. 153.—Laurent, Ann. Ch. Phys.
guti, *ibid.* lxiv. 151.)—Obtained by distilling camphoric or ethyl-
d crystallising the product from boiling alcohol. It forms fine prisms
tion, and having no perceptible taste at first, but afterwards irri-
t. It dissolves very sparingly in cold water, a little more in boiling
lantly in alcohol, still more in ether. At 130° C. it begins to sublime
needles, melts to a colourless liquid at 217°, begins to boil above
ithout residue. Specific gravity of the crystals 1·194 at 20°·5. They
friction, like resins. Their solution does not precipitate neutral

ydride boiled with water dissolves very slowly as camphoric acid.
n is effected much more quickly by alkalis. It does not absorb dry
aqueous or alcoholic ammonia converts it into camphoramate of
ted with phenlyamine, it yields phenylcamphoramate of phenylam-
ylcamphorimide. Heated with strong sulphuric acid, it gives off
d is converted into sulphocamphoric acid (*q. v.*)

$$\underset{\substack{\text{Camphoric}\\\text{anhydride.}}}{C^{10}H^{14}O^3} + H^2SO^4 = \underset{\substack{\text{Sulpho-}\\\text{camphoric}\\\text{acid.}}}{C^9H^{16}SO^6} + CO$$

C ETHERS. *Camphorate of Ethyl.* $C^{14}H^{24}O^4 = C^{10}H^{14}$
body is formed in the dry distillation of ethyl-camphoric acid,
y pouring water into the alcoholic mother-liquors from which the
recipitated. It is purified by boiling with alkalised water, drying
shing, distilling, and again drying in vacuo. It is an oil having a
r, a very disagreeable bitter taste, and a powerful odour. Specific
6° C. Begins to boil at 285° or 287°; turns brown a few degrees
a black residue, but the distillate is very pure after being washed.
tral and insoluble in water. Potash decomposes it like other ethers;
solves it in the cold without decomposition; at higher temperatures,
es place, but without blackening or evolution of sulphurous acid.
y hydrochloric or nitric acid, either cold or hot. (Malaguti, Ann.
1.)

l Camphorate of ethyl, $C^{14}H^{20}Cl^4O^4$, is produced by the action of
orate of ethyl. Neutral; has a bitter persistent taste. Soluble
er. Specific gravity 1·386 at 14° C. When heated it becomes very
oses before boiling. Aqueous potash scarcely attacks it, but alcoholic
into camphorate, acetate, and chloride of potassium:

$$^4 + 8KHO = C^{10}H^{14}K^2O^4 + 2C^2H^3KO^2 + 4KCl + 4H^2O.$$

Ch. Phys. lxx. 360.)

f Ethyl and Hydrogen. *Ethyl-camphoric* or *Camphovinic acid.*
$^4(C^2H^5.H)O^4$.—When a mixture of 2 pts. camphoric acid, 4 pts. ab-
1 pt. sulphuric acid is boiled and cohobated several times, a residue
, when diluted with water, yields an oily deposit of ethyl-camphoric

acid. This acid has, at ordinary temperatures, the consistence of treacle. I
parent and colourless, has a peculiar odour and a very agreeable taste, not
bitter. It dissolves very sparingly in alcohol and ether. Specific gravity
20·5° C; reddens litmus paper after a while only; dissolves in alkaline solu
is decomposed when boiled with them. Water effects the same decomposi
long contact or continued ebullition. By dry distillation it yields water,
anhydride, and camphorate of ethyl, together with very small quantities of a
carburetted hydrogen gas, resulting from secondary decomposition :

$$\underset{\text{Ethyl-camphoric acid.}}{2C^{12}H^{20}O^4} = H^2O + \underset{\text{Camphoric anhydride.}}{C^{10}H^{14}O^3} + \underset{\text{Camphoric ether.}}{C^{14}H^{24}O^4}$$

The alcoholic solution gives a copious precipitate with neutral acetate of le
laguti.)

Ethyl-camphoric acid is monobasic, the formula of its salts being $C^{10}H^{14}(C$
The *ammonium*, *potassium*, *sodium*, *barium*, *strontium*, *calcium*, and *magne*
are soluble in water. The *zinc*, *copper*, *lead*, *mercury*, and *silver*-salts are
or sparingly soluble. The copper-salt, obtained by precipitating sulphate
with ethyl-camphorate of ammonia, is probably a sesquibasic salt. (Mala
Ch. Phys. lxiv. 151.)

Camphorate of Methyl and Hydrogen. Methyl-camphoric or *Camp*
acid. $C^{11}H^{18}O^4 = C^{10}H^{14}(CH^3.H)O^4$.—Obtained in the same manner as
phoric acid, substituting wood-spirit for alcohol. The residue of the third
yields, when washed with water and left at rest, a crystalline mass, whic
pressed between paper and boiled with water. It then forms an acid liqu
bottom of which some drops of oil collect, changing after a few days
defined, colourless, shining crystals of methyl-camphoric acid. These c
either needles arranged in radiating groups, or small four-sided or six-side
but on dissolving them in ether and leaving the solution to evaporate v
well formed prisms are obtained belonging to the trimetric system, and
the combination, $P . \infty P . \infty \breve{P} \infty$. Inclination of the faces, $\infty P : \infty P =$
$\infty \breve{P} \infty : \infty P = 126° 45'$; $\infty P \infty : P = 115° 25'$ and $66° 4'$; $P : P = 160$
four-sided laminæ are hemihedral, and exhibit only the combination $\frac{P}{2}$. 8
cleavage perpendicular to $\infty \breve{P} \infty$.

Methylcamphoric acid is very little soluble in water, very soluble in alco
and chloroform. The solutions are strongly acid, and turn the plane of pola
a ray of light to the right: $[\alpha] = + 51° 4'$. The acid melts at about 68°
mains viscid a long time after cooling. By distillation it yields camphoric
a viscid liquid, and a slight residue of carbon. Boiled with caustic potash,
wood-spirit and is converted into camphorate of potassium.

The aqueous and alcoholic solutions of the acid form a white crystalline
with acetate of lead, soluble in excess of the acetate; with acetate of copper,
crystalline precipitate; with baryta-water, they form a cloud, which disappea
ing a drop of nitric acid. They have no action on lime-water or on solub
salts, but form a slight cloud with nitrate of silver. Oxide of silver is r
them, producing a blackish deposit. (Low, Ann. Ch. Phys. xxxviii. 483.)

CAMPHORIMIDE. $C^{10}H^{15}NO^2 = N.H.(C^{10}H^{14}O^2)''$.—Obtained b
neutral camphoramate of ammonium to 150° or 160° C., or by melting or dist
phoramic acid:

$$\underset{\text{Camphoramic acid.}}{C^{10}H^{17}NO^3} = \underset{\text{Camphorimide.}}{C^{10}H^{15}NO^2} + H^2O$$

and: $$\underset{\text{Camphoramate of ammonium.}}{C^{10}H^{16}(NH^4)NO^3} = \underset{\text{Camphorimide.}}{C^{10}H^{15}NO^2} + NH^3 + H^2O.$$

It is purified by solution in boiling alcohol and crystallises on cooling. It
less, volatilises at a high temperature without decomposition, and dissolves
boiling alcohol, crystallising, on cooling, in tufts like fern leaves, beautifully
or by very slow cooling in hexagonal tables, oblique and much elongated.
solution in weak alcohol, it is gradually deposited in the form of a gummy, t
substance, which solidifies after some hours in opaque tubercles. The alco
tion gives off ammonia when boiled with potash. It dissolves at a gentle hea
sulphuric acid, and, on pouring a few drops of water into the solution, a
talline deposit is formed. (Laurent, Compt. chim. 1845, p. 147.)

CAMPHORIN. *Camphorate of Glyceryl.*—Produced by heating camp

iscid; soluble in ether; decomposed by oxide of lead, yielding gly-
rate of lead. (Berthelot.)

NE. *Phorone* (Gerhardt); *Camphoryl* (Laurent). $C^9H^{14}O$. —
he acetone of camphoric acid, was first obtained in an impure state,
ie decomposition of that acid, by Laurent (Ann. Ch. Phys. [2] lxv.
prepared pure and more thoroughly examined by Gerhardt and
ompt. chim. 1849, p. 385).
produced, like other acetones, by the dry distillation of the calcium-

$$\underset{\text{Camphorate of calcium.}}{C^{10}H^{14}O.Ca''.O^2} = \underset{\text{Carbonate of calcium.}}{CO.Ca''.O^2} + \underset{\text{Camphorone.}}{C^9H^{14}O}$$

rate only on small quantities at a time. The brown or yellow oil
is purified by fractional distillation, a small quantity of tar remain-

likewise obtained, together with other products, by distilling with
following substances: 1. *Acetic acetone*, which differs from it only by
ater ($3C^3H^6O - 2H^2O = C^9H^{14}O$). On rectifying the distillate, oxide of
passes over at about 131° C., and camphorone between 200° and 205°
h. Pharm. cx. 33).—2. *Grape-sugar*. The distillate yields on recti-
iling at 86° C., having the composition of metacetone, $C^{18}H^{30}O^3$ (and
nphorone, or a body isomeric with it, by distillation with phosphoric
camphorone passes over at 208° (Liès-Bodart, Compt. rend. xliii.
ice of *ripe mountain-ash berries*, which contains a small quantity of
method, however, does not always yield it. (Liès-Bodart, *loc. cit.*)
a colourless or yellowish oil, very mobile, lighter than water: and
dour like that of peppermint. It boils at 208° C. (Gerhardt), and
mposed, yielding a vapour whose density = 4·982 (Gerhardt and
by calculation for 2 vol. = 4·784. It is insoluble in water, but dis-
and very readily in ether. It does not unite either with acids or
according to Limpricht (Ann. Ch. Pharm. xciv. 246), differs from
not combining with acid-sulphites of alkali-metals.
ecomes darker in colour when exposed to the air. It dissolves with
in strong sulphuric acid, and is for the most part precipitated there-
It is resinised by nitric acid. Phosphoric anhydride acts quickly
temperature, converting it, by abstraction of water, into cumene, C^9H^{12}
which passes over in fractional distillation at 170° C., a carbonaceous
ehind. Pentachloride of phosphorus converts it into a chlorinated
ing at 175° C., lighter than water, insoluble therein, easily soluble in
coholic solution, saturated with ammonia-gas, yielded a crystalline
oly $C^9H^{15}N.HCl$ (Liès-Bodart). Camphorone heated with *potas-*
hydrogen, and appears to form the compound $C^9H^{13}KO$ (Liès-
potash-lime it becomes heated, and appears to enter into combination;
ted to 240° C. gives off a colourless oil, apparently different from
le a resinous substance remains with the alkali. (Gerhardt and

YL. $C^{10}H^{14}O^2$. The diatomic radicle of camphoric acid, &c. The
pplied by Laurent to camphorone.

LPHURIC ACID. See Sulphocamphoric Acid.

INIC ACID. Camphorate of Ethyl and Hydrogen. (See Camphoric

NE. A product of the decompsition of camphor by sulphuric acid

NE. $C^{30}H^{44}O$.—A liquid produced by passing camphor over red-hot
ght oil, having a strong and peculiar odour, quite different from that
boils at 75° C., is insoluble in water, soluble in alcohol and in ether.
om camphor by abstraction of water ($3C^{10}H^{16}O - 2H^2O = C^{30}H^{44}O$),
lentical with the product obtained by heating camphor with clay, or
apour of camphor through a red-hot porcelain tube. (Frémy, Ann.
. 16.)

. See Barwood (p. 517).

TE. A greyish scapolite rock, from Canaan, Connecticut, containing
iO², 4·10 Fe^2O^3, 10·38 Al^2O^3, 25·80 CaO, 1·62 MgO, and 4·00 CO^2.

ALSAM. See Balsams (p. 492).

CANCERIN. An artificial guano from Newfoundland.

CANCHA-LAGUA. See CACHA-LAGUA (p. 701).

CANCRINITE. A massive mineral found near Miask in the Ural, in the kaja mine in the Tunskinsk mountains, Siberia, and in Litchfield in the State It cleaves parallel to the faces of a hexagonal prism, has an uneven fracture, red colour and waxy lustre, nacreous on the cleavage faces; transparent o translucent. Specific gravity 2·45 to 2·46. Hardness 5·0—5·5. It melts tumefied glass. Hydrochloric acid dissolves it readily, with efflorescence a tion of gelatinous silica.

The following are analyses of cancrinite: 1. From Miask; light red: gravity 2·453 (G. Rose, Pogg. Ann. xlvii. 375); *b.* Specific gravity 2·48 rewsky, Kokscharow's *Materialen zur Mineralogie Russlands*, i. 81).—2. Tunskinsk Mountains, yellow; *a.* Specific gravity 2·449 (Struve, Pogg. 613); *b.* Specific gravity 2·448 (Pusirewsky).—3. From Litchfield. Specific gravity 2·448; *b.* Greenish. Specific gravity 2·461. (Whitney, 431.)

	From Miask.		From the Tunskinsk Mts.		From
	G. Rose.	Pusirewsky.	Struve.	Pusirewsky.	Whitney.
Carbonic anhydride	6·38	5·55	8·51*	5·61	5·95
Silica	40·43	35·96	38·33	37·72	37·72
Alumina	28·227	29·57	28·55	27·27	27·55
Ferric and Manganic oxides	—	0·19	—	—	0·75
Lime	6·70	5·68	4·24	3·11	3·87
Soda	17·52	18·53	20·37	21·60	20·27
Potash	0·70	—	—	—	0·67
Water	—	3·69	—	4·07	2·82
SO^3		0·32			
	100·00	99·49	100·00	99·86	99·60

From these results, Rammelsberg concludes that the mineral is a mixt bonate of calcium with elæolite, containing a smaller proportion of potash water than the usual amount. (Rammelsberg's *Mineralchemie*, p. 653; 232.)

CANDITE. See SPINEL.

CANELLA ALBA. *Costus dulcis. White Cinnamon.*—These nam plied to the bass or inner bark of *Canella alba*, a canellaceous tree growing i Indies, especially in Jamaica. It forms reddish-yellow tubes, three feet lo inch thick, having a pleasant aromatic taste and odour: it contains about of manna (formerly mistaken for a peculiar kind of sugar called *canellin* starch and the other usual constituents of vegetable structures. By distill water, it yields two volatile oils, one lighter than water, the other heavier. oils be left in contact with potash-ley, the liquid then diluted with water an the first portion of the distillate is again lighter than water, and at last a h obtained, of very peculiar odour. The potash-ley from which the oils have tilled, yields by neutralisation with acid and distillation, a heavy oil, smelli of cloves. The light oil of white cinnamon smells very much like oil of ca may be separated by fractional distillation into several oils, differing greatly point. White cinnamon contains about 6 per cent. of ash, consisting mai bonate of calcium. (Handw. d. Chem. ii. [2] 927.)

CANNAMINE. Syn. of BRUCINE.

CANNABIN. A poisonous resin extracted from hemp, by exhausting t plant (*Gunjah*) with alcohol, after the greater part of the brown colouring been removed by digestion, first in tepid water, afterwards in solution of ca sodium, then precipitating the chlorophyll with lime, decolorising with anim and evaporating. (T. and H. Smith, Pharm. J. Trans. vi. 127, 171.)

From the *Extract. hb. canab. ind. spirituos.* G. Martius has prepared a treating it with cold alcohol of 83 per cent., mixing the dark green filtrate till turbidity ensues, agitating with animal charcoal, filtering and distilli alcohol: the resin then separates. It is a light brown, shining substance, glutinous and ductile, has a peculiar narcotic odour, like that of the extract, tensely bitter taste. It melts at 68° C., burns with a bright smoky flame, i in potash and ammonia, but dissolves in alcohol and ether, sparingly al Volatile oils dissolve it in the cold; fixed oils, with aid of heat.

The narcotic effects of haschish (*q. v.*) are due to hemp-resin. (Handw. d [2] 727.)

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* Carbonic anhydride and water.

INDICA. *Indian Hemp.*—This plant, which is indigenous in
nor, is much used in the East as an intoxicating agent; the narcotic
reside essentially in a resinous exudation (see Cannabin and
ding to Martius (Chem. Centr. 1856, 225), the herb contains a
ssential oil. The herb dried at 100° C. yielded 18·1 per cent. ash,
ion of carbonic anhydride and sand, contained in 100 pts.: 13·6
2·0 lime, 10·4 magnesia, 8·8 phosphate of iron, 10·1 phosphoric an-
ric anhydride, 1·2 chlorine, and 22·1 silica.

SATIVA. *Common hemp.*—The leaves of this plant contain 40·5
9 hydrogen, 1·8 nitrogen, and 22·0 ash; the stems: 39·9 per cent. C,
·5 ash. (Kane, J. pr. Chem. xxxii. 354.)
er. f. Chem. 1850, Tafel C. p. 661), found in the hemp-plant 4·6
he seed 6·3 per cent. The analyses of the ash of the entire plant
given in the following table:

O	Na^{2}O	CaO	MgO	Al^{2}O^3	Fe^{2}O^3	SO^3	SiO^2	P^{2}O^5	Cl	CO^2
·5	0·7	42·0	4·9	0·4	—	1·0	6·7	3·2	1·5	31·9
·8	3·4	35·5	7·7	—	1·1	2·7	7·7	14·2	3·4	8·4
·5	0·8	20·2	10·2	—	1·2	0·2	9·6	37·6	0·1	1·3

htweiss (Ann. Ch. Pharm. l. 416), hempseed yields 5·6 per cent.
·8 K^{2}O, 0·6 Na^{2}O, 25·6 CaO, 1·0 MgO, 33·5 P^{2}O^5, 13·5 SiO^2, 6·2
and small quantities of sulphuric acid, chloride of sodium, and ferric

s 31·8 per cent. oil, 22·6 albumin, and 6·37 ash, of which 2·47 con-
s (Anderson, Highland Agr. Soc. Journal [new series] No. 50).
, and yields with chlorine and bromine, the substitution-products
^{11}H^{20}Br$'$O^2. (Lefort, Compt. rend. xxxv. 134.)
vers, and pollen of hemp have been examined by Schlesinger,
190). The ash of the leaves contains 8·0 per cent. soluble, and
ble salts. (Kane.)

AL. See Coal.

ETAL. See Copper, Alloys of.

DES. *Spanish Flies* (*Lytta vesicatoria.*)—These coleopterous in
n for their vesicating properties, are much used in medicine in the
plasters, &c. Their vesicating power is due to a peculiar acrid
ntharidin. Taken internally, they act as a powerful aphrodisiac,
roy life. According to Thoury (J. Pharm. Jan. 1858, p. 65), their
ay be counteracted by the administration of animal charcoal.
us extract of cantharides is treated with alcohol, cantharidin is dis-
ith other substances, and a brown nitrogenous substance remains.
e alcoholic extract and treating the residue with ether, the cantha-
gether with a yellow substance, and an extractive matter remains,
nus and contains lactic acid, together with a nitrogenous substance.
tion of cantharides reddens litmus strongly, and gives with ammonia
monio-magnesian phosphate (Robiquet, Ann. Ch. lxxvi. 302). When
eing exhausted with boiling water, are treated with boiling alcohol,
dissolves, destitute of vesicating power, and consisting, according to
h. Pharm. lxxxvi. 317), of olein, stearin, and palmitin.

DIN. C^{5}H^{12}O^2. Isomeric with picrotoxin. (Robiquet, *loc. cit.*;
Ch. Phys. [2] lxviii. 151; Thierry, J. Pharm. xxi. 44; Warner,
xxviii. 193; Procter, Pharm. J. Trans. xxi. 44.)—This substance,
e principle of the Spanish fly, is likewise found in the following
ts:—*Lytta vittata*, *L. ruficollis*, *L. gigas*; *Mylabris cichorii* (Chinese
ustulata, *M. punctum*, *M. Sidæ*, *M. Schoenherri*; *Meloe violaceus*,
. Furca, *M. punctatus*, *M. variegatus*, *M. scabrosus*, *M. majalis.*
ner, *Lytta vesicatoria*, *L. vittata*, and *Mylabris cichorii* contain about
ntharidin. According to Ferrer, *Mylabris punctatus* contains 0·33
tum 0·19, *M. cichorii* 0·10, *M. Sidæ* 0·12, *M. Schoenherrii* 0·15 per

prepared from Spanish flies, or better from *Mylabris cichorii*, inas-
ect contains less fat, by digesting the pulverised insects for some
ther-alcohol, or alcohol alone; completing the extraction in a dis-
tus, the ether or alcohol being ultimately displaced by water; and
ther or alcohol. The cantharidin, which crystallises out on cooling,
purified with animal charcoal. Ether is preferable to alcohol for

the preparation, since it dissolves less of a green oil, which adheres obstinate cantharidin (Thierry). According to Procter, cantharidin is best extracted b form. The pulverised cantharides are left in contact for some time with tw weight of chloroform in a displacement apparatus; the chloroform is then dr and finally displaced by alcohol, and the solution is left to evaporate, where cantharidin crystallises out, saturated with the green oil. It is laid on bibulo which absorbs the greater part of the oil, then crystallised from chlorofor with alcohol.

Pure cantharidin forms colourless right-angled four-sided prisms of the system, acuminated with four faces resting on the lateral faces. According t it crystallises from ether in oblique four-sided prisms, with dihedral summit the aspect of micaceous laminæ. It melts at 200° C., and volatilises in whi which strongly irritate the eyes, nose, and throat, and condense in rectangula having a strong lustre, and sometimes iridescent.

Cantharidin *per se* is insoluble in *water*, but it is rendered soluble by the p other substances (see the last article). It volatilises in small quantity at 10 more quickly at 182°; not with vapour of water. It dissolves readily in *alco* pts. of cold *ether*, and rather less of hot ether; *acetic ether*, *wood-spirit*, an also dissolve it readily when hot, and deposit it on cooling. But its best *chloroform*, which extracts it even from the aqueous infusion of cantharides. wise dissolves in *oils*, both fixed and volatile. Its solution in any of the liqui mentioned possesses the vesicating power, which, however, is not exhi cantharidin in the solid state. A grain of cantharidin mixed with an ounc produces very strong vesication. Cantharidin dissolves in *sulphuric acid*, precipitated by water; also in hot *hydrochloric* and *nitric acids*, whence it c on cooling; *phosphoric*, *acetic*, and *formic acids* dissolve but little of it at ordi peratures. It dissolves in *potash-ley*, and is precipitated by acetic acid. has no action upon it.

CANTONITE. A variety of sulphide of copper, $Cu''S$, from the Canto Georgia, having hexahedral cleavage, bluish-black colour, and semi-metall Specific gravity = 4·18. Hardness = 2·0 (N. A. Pratt, Sill. Am. J. [2] x Genth (*ibid.* 417) regards it as a pseudomorph of covellin after galena.

CANTON'S PHOSPHORUS. A phosphorescent substance prepare cining for an hour, at a red heat in a crucible, a mixture of 3 pts. of finel oyster-shells with 1 pt. of flowers of sulphur. A better phosphorescence is by calcining the entire shell in a closed crucible, after dusting it over with Exposure to bright light is necessary to its luminosity in the dark. The in the shells is said to be essential to the effect. Gypsum mixed with flou phosphorescent when calcined.

CAOUTCHENE. A hydrocarbon, isomeric with tetrylene, C^4H^8, said chardat (J. Pharm. Sept. 1837, p. 454), to be produced, together with othe dry distillation of caoutchouc (*q. v.*) It has a density of 0·65, boils at 14·5 solidifies in brilliant needles at −10°.

CAOUTCHIN. $C^{10}H^{16}$. (Himly, Ann. Ch. Pharm. xxvii. 41; Gr. W Proceedings of the Royal Society, x. 517; Gm. xiv. 326.)—A hydrocarbon together with many other substances, in the oils produced by distillation of c and gutta percha. To separate it, rectified oil of caoutchouc boiling between 280° C., is repeatedly shaken up with dilute sulphuric acid, then washed a with water and potash-ley, and distilled with water several times. The di dehydrated with chloride of calcium and rectified *per se*, the portion which d tween 160° and 175°, being collected apart; from this, by repeated rectific removal of the portions which pass over below 166° and above 174°, caout length obtained, boiling between 168° and 171°; and this product, by repe tional distillation, may be brought to boil at 171°. The purification ma effected by passing dry hydrochloric acid gas into the cooled oil, previously d chloride of calcium, whereby hydrochlorate of caoutchin is produced; decan liquid from the resin, after it has stood for some days; dissolving it in ab cohol; precipitating with water; dehydrating it, and decomposing it by di over caustic lime or baryta, and finally over potassium. The product thus is pure caoutchin. (Himly.)

Caoutchin is a transparent, colourless, mobile liquid, having an odour lik oil of orange, but not quite so agreeable, and a peculiar aromatic taste. transient grease spots on paper. Specific gravity 0·8423 at 0° C. Boils at 0·75 met. pressure. Does not solidify at −39°. Vapour-density 4·461 (Him (Williams), by calculation (2 vols.) = 4·714. It has but little electric co power.

olves in 2000 pts. of *water*. It likewise takes up a small quantity of
, and at higher temperatures a larger quantity, which separates on
olves in all proportions of *alcohol*, *ether*, and *acetate of ethyl;* water
the alcoholic, but not from the ethereal solution, unless alcohol be
. The alcoholic solution burns with a bright flame, which does not
tchin and alcohol have been mixed in the right proportion. It dis-
concentrated *acetic* and *formic* acids; also in *oils* both fixed and

rbs *oxygen* from the air (45 vols. in fourteen days), and is converted
of it, however, volatilising. It is likewise resinised by various *oxidis-*
y *peroxide of hydrogen*, *nitric oxide*, *nitrous acid*, *strong nitric acid*,
romic acid;* it reduces *cupric oxide* to cuprous oxide and *permanganate*
eroxide of manganese, but exerts no deoxidising action, even at the
e oxides of lead, mercuric oxide, or chromate of potassium. It is like-
y sodium, potash, baryta, or lime. With *potassium* it evolves a few
covers the metal with a grey film, then remains unaltered.
outchin absorbs 2 vols. in three weeks at 20° C.; of *carbonic anhy-*
rbonic oxide, marsh-gas and olefiant-gas are not absorbed by it. Of
bs 5 vols. in five weeks; of *nitrous oxide* a small quantity; *nitric oxide*
after a while. It absorbs 3 vols. *ammonia-gas*, but does not mix with
. It does not absorb cyanogen gas, but *hydrocyanic acid* and *chloride*
bsorbed by it in any quantity. It dissolves *phosphorus* and *sulphur*
old, rather more freely when heated; does not absorb sulphydric acid
all proportions with *sulphide of carbon* and *xanthic acid*. It ab-
c, *hydrobromic*, and *hydriodic acid gases*, forming the compounds
It easily dissolves the *chlorides of sulphur*, *phosphorus*, and *carbon*,
f *iodide of sulphur*, and *iodide of phosphorus*. It dissolves a large
c, and a small quantity of *oxalic acid;* but not malic, citric, tartrate,
succinic acid.

ped into strong *sulphuric acid*, becomes heated, eliminates sulphurous
rms a brown unctuous acid, $C^{10}H^{16}SO^3$, which forms soluble barium
the latter having, according to Williams, the formula $\grave{Ca}(C^{10}H^{15}SO^3)^2$.
g *selenic acid*, it turns brown and gradually decomposes. It is not
osphoric or *phosphorous acid*.

caoutchin gives off hydrochloric acid and forms chlorocaoutchin,
ing with soda-ley, then with water, and dehydration over chloride of
ransparent, colourless, neutral, viscid liquid, of specific gravity 1·433,
ethereal odour and extremely sharp burning taste. It dissolves
r, easily in alcohol and ether, gives off irritating vapours of hydro-
distilled *per se*, and yields a variety of oily products by distillation

caoutchin gives off hydrobromic acid, but remains colourless and
sily separates bromine from its solution in water, alcohol, or ether,
ops of oil. Caoutchin mixed with ⅕ vol. water decolorises bromine
mine have been added to 100 pts. caoutchin, which is in the ratio
o 1 at. caoutchin.

e action of *bromine* and *sodium* on caoutchin, 2 at. hydrogen are re-
e, $C^{10}H^{14}$, is produced. (Williams.)

aoutchin turns black, and gives off hydriodic acid. It abstracts
on in water, alcohol, or ether, forming iodocaoutchin, which is a
giving off hydriodic acid when distilled, easily decomposed by heating
bromine, chlorine, fuming nitric acid, or potash, nearly insoluble in
in alcohol or ether. Caoutchin distilled with excess of iodine, forms
nt oil.

f Caoutchin, $C^{10}H^{16}.HCl$.—This compound is prepared by passing dry
caoutchin cooled with ice, the delivery-tube terminating a little
of the liquid,—washing the product first with soda-ley, then with
over chloride of calcium. It is also produced, though in an impure
caoutchin with trichloride of antimony or mercuric chloride. It is a
less, neutral, viscid liquid, having a strong ethereal odour and a very
te. Specific gravity 1·433. It gives off very irritating vapours of
when distilled; is decomposed by boiling with sulphuric acid, with
rochloric acid; and yields a variety of oily products by distillation
or baryta. It dissolves sparingly in water, easily in alcohol and
nitric acid and sulphuric acid, separating out unchanged on cooling;
g with the latter, it becomes carbonised and gives off hydrochloric

CAOUTCHOUC. *Gum elastic*, or *India Rubber. Gomme élastique. Federharz.*—A product of several genera of arboraceous plants, in which it occurs in the form of a milky sap, and exudes from incisions made in their trunks. Among these trees are the *Siphonia elastica, S. Cahuchu, Hevea caoutchouc, H. Guianensis, Jatropha elastica, Ficus elastica, F. indica, F. religiosa.* Formerly the greater part of the good caoutchouc was imported from Para in South America, but an excellent article has of late years been brought from Assam and other districts of India, in which the trees that yield it greatly abound. The juice drawn from the old trees and in the cold season is preferable to that from the young trees and in the hot season, the quantity being greater the higher the incision is made across and through the bark of the tree. The fluid is of a creamy consistence and colour. Its specific gravity, as imported into this country in well-closed vessels, used to vary from 1·0175 to 1·04125 (Ure); the lighter juice yielded 37 per cent. of solid caoutchouc; the denser only 20, though it was the thicker of the two. Some samples of juice have a brownish tinge, proceeding from a little aloetic matter secreted together with it, which, if dried up in the juice, gives the caoutchouc a certain degree of viscidity, and by its decomposition eventually destroys its firm texture. Such juice ought to be mixed with its own bulk of water and boiled, whereby the aloes are separated and the caoutchouc concretes into a white elastic mass, free from offensive smell.

Much of the caoutchouc is imported in coarse rough masses. These are cleaned by washing in a trough, with a stream of water, and afterwards kneaded together by the strong pressure of iron-arms in an iron box. The masses thus obtained are next moulded into the forms of square or round cheeses in a press, and finally sliced by knives driven by machinery into thin cakes or ribbands. U.

Faraday recommends for the purification of caoutchouc, to dilute the natural juice with four times its weight of water, and leave it at rest for twenty-four hours. The caoutchouc then separates and rises to the surface in the form of a cream. This is removed, diffused through a fresh quantity of water, and again left to settle at the surface. By repeating this operation till the wash-water is perfectly limpid, the caoutchouc may be obtained very nearly pure. It is then to be spread upon a plate of unglazed earthenware to absorb the water, and afterwards pressed.

Pure caoutchouc is colourless and transparent, but the best found in commerce has a more or less dingy colour from having been dried from the juice in a smoky atmosphere. It is a bad conductor of heat, and a non-conductor of electricity. It is very combustible, and burns without residue, emitting a white light. At ordinary temperatures, it is soft, flexible, and highly elastic. Freshly cut surfaces adhere easily and firmly when pressed together, a property which is made available in forming tubes and vessels out of sheet-caoutchouc. Below 0° C. it becomes hard and rigid. When heated, it gradually softens, and at 120° C. (248° F.) begins to melt; when it is fused, it remains greasy and semi-fluid after cooling, but if exposed to the air in thin layers, gradually dries up and recovers its original properties, provided it has not been heated much above its melting point. If, however, it be heated to 200° C. (398° F.) it begins to fume, and is converted into a viscid mass which no longer dries up. If mixed in this state with half its weight of lime slaked to powder, it forms a tenacious non-drying cement, which serves admirably for attaching glass-plates to vessels with ground lips, such as are used for preserving anatomical preparations, as it forms an air-tight, but easily-loosened joint; if a drying cement be required, a quantity of red lead may be added equal in weight to the lime.

According to the experiments of Ure (Phil. Trans. 1822), confirmed by those of Faraday (Quart. Journal of Sc. Lit. and Art, xi. 19), caoutchouc is composed wholly of carbon and hydrogen, containing 87·5 per cent. of carbon, and 12·5 hydrogen. It is not, however, a simple proximate principle, but chiefly a mixture of two substances, one much more soluble in ether, benzene, and other liquids than the other.

On examining with the microscope a thin sheet of caoutchouc, it is seen to be filled with irregularly rounded pores, partly communicating with each other, and dilating under the influence of liquids. It is perfectly insoluble in water and alcohol; but ether, benzene, rock-oil, and sulphide of carbon, penetrate it rapidly, causing it to swell up and apparently dissolving it.

The liquid thus formed, is not, however, a complete solution, but a mixture formed by the interposition of the dissolved portion between the pores of the insoluble substance, which is considerably swelled up, and has thus become easy to disintegrate. By employing a sufficient quantity of these solvents, renewed from time to time, without agitation, so as not to break the tumefied portion, the caoutchouc may be completely separated into two parts, viz. a substance perfectly soluble, ductile, and adhering strongly to the surface of bodies to which it is applied; and another substance, elastic, tenacious, and sparingly soluble. The proportions of these two principles vary with the quantity of the caoutchouc and the nature of the solvent employed. Anhydrous

from amber-coloured caoutchouc 66 per cent. of white soluble matter;
ne separates from common caoutchouc 49 per cent. of soluble matter
colour.

vent for caoutchouc is a mixture of 6 to 8 pts. of absolute alcohol and
hide of carbon. (Payen.)

is not altered by dilute acids. Strong sulphuric acid acts slowly, and
acid rapidly on it, the latter with complete decomposition. It resists
-leys, even at the boiling heat.

yields by *dry distillation*, an empyreumatic oil called **oil of caoutchouc**
cin, which forms an excellent solvent for caoutchouc and other resins. It
a considerable number of hydrocarbons. Ordinary impure caoutchouc
small quantities of carbonic anhydride, carbonic oxide, water, and

he nature of the hydrocarbons contained in caoutchouc-oil, different ex-
ve arrived at somewhat different results. According to Bouchardat
ii. 457), the most volatile of the hydrocarbons has a density of 0·63 at
at a temperature above 0° C., is not solidified by cold, and is perhaps
etrylene, C^4H^8. The next, **caoutchene**, isomeric with the first, has
65, boils at 14·5° C., and solidifies at $-15°$ in brilliant needles which

atile portion of the oil, which does not distil till the temperature is
C. and does not solidify at the lowest temperatures, is called **heveene**.
low oil of specific gravity 0·921 at 19° C. and belonging to the ole-
^{2n}. It mixes with alcohol and ether, absorbs chlorine quickly, and
vaxy mass. By repeated treatment with strong sulphuric acid and
converted into an oil, boiling at 228° C., having a sweeter and more
than heveene, and similar in many respects to eupione. (Bouchardat.)
l. Mag. [3] lvi. 579), by subjecting caoutchouc-oil to repeated fractional
ained: 1. An oil called *Faradayin*, boiling at 33° C., of specific gravity
olved by strong sulphuric acid without evolution of sulphurous anhy-
ing to Liebig, water separates from this solution a colourless oil boil-
According to Gregory, both this and the more volatile oils belong
olefines, C^nH^{2n}. The oil unites with chlorine and bromine, forming
—2. A mixture of oils distilling at 96° C. from which potash extracts
lute sulphuric acid separates a brown resin, destroying the odour at the
ccording to Himly, the percentage of carbon in these oils increases as
t rises.—3. **Caoutchin** (p. 736).

rocarbon, **isoprene**, polymeric with caoutchin, and boiling at 37—
obtained by Gr. Williams (Proc. Roy. Soc. x. 56), from the distillation
From the composition of these several hydrocarbons, it appears that
on of caoutchouc by heat is merely the disruption of a hydrocarbon into
s polymeric with it.

left in the retort, after the volatile oil of caoutchouc has distilled off,
solved in the oil, a varnish much used by shipwrights, being impervious
very elastic. An exceedingly tenacious glue is also made by dissolving
ouc, cut up into small pieces, in 4 pts. of coal-tar, adding 2 pts. of
e solution is complete, and heating the whole in an iron vessel.

CAOUTCHOUC. — When caoutchouc is kneaded in an iron box with
ur heated to about 112° C. (234° F.), it takes up a certain portion of
equires new properties which greatly increase its utility for various
arts. It remains perfectly flexible at temperatures below 0° C. and
at 50° C. (122 F.), whereas ordinary caoutchouc becomes perfectly rigid
several degrees above the freezing point, while a moderate heat ren-
d adhesive as to be useless. This sulphured or *vulcanised* caoutchouc,
aterial for tubes for conveying water or gases, or for bags to hold gases

tion of caoutchouc requires a temperature of about 150° C. (304° F.),
few minutes only. A longer contact with sulphur at that temperature
tchouc to absorb too much, which renders it hard and brittle. Vulca-
c appears to retain only one or two-hundredths of its weight of sulphur
combination; a larger quantity, 15 or 20 per cent., remains simply
een the pores, and may be extracted either by the action of solvents,
enzene, and sulphide of carbon, or by friction, or alternate extension
If the vulcanised caoutchouc be heated to 120° C., this mechanically
ur enters into combination with the caoutchouc and renders it brittle.
ination takes place slowly at ordinary temperatures, so that the caout-
time, loses its elasticity and becomes brittle. By contact with certain

metals, such as lead or silver, the free sulphur in the pores of the caoutchou stracted, and thus again the quality is deteriorated.

The vulcanisation of caoutchouc is effected in various ways: 1. By immers sheet-caoutchouc in flowers of sulphur heated to 112° C. till it has absorbed a of its weight, and then heating it for a short time to 150° C., or by immers caoutchouc in flowers of sulphur heated to 150°, and keeping up that tempera the sulphuration is complete.—2. By immersing the caoutchouc in a mixture of sulphide of carbon, and 2·5 protochloride of sulphur, and then plunging water to decompose the excess of chloride of sulphur.—3. By immersing art caoutchouc already manufactured, in a solution of polysulphide of calcium 25° Baumé, keeping them in it for three hours in a closed vessel at 140° C., a washing them with weak alkaline-ley of 60° Bm. This process always yie right amount of sulphuration.—4. By powdering 100 pts. of the caoutchouc i laminæ, with a mixture of 4 pts. flowers of sulphur and 50 pts. slaked lime, pre between rollers so as to incorporate it thoroughly with the powder, then wo into various fabrics by the usual processes, and exposing the finished articles hour to the action of vapour of water. By this last treatment, the surface caoutchouc experiences a kind of washing, which removes the excess of sulp calcium, and brings it to the exact degree of sulphuration required.

Hardened Caoutchouc. Ebonite. — Caoutchouc may be hardened and rende ceptible of polish by mixing it in the kneading machine or between roller half its weight of sulphur, rolling the mass into sheets, and heating it for tw to 100° C., and then for four hours to 150°. At the latter temperature, the m be rolled; when cold it may be cut like ivory. It serves for the manufa combs, knife-handles, buttons, &c. It is also preeminently distinguished by t quantity of electricity which it evolves when rubbed, and is therefore a adapted for the plates of electrical machines. It resists the action of solve more obstinately than elastic vulcanised caoutchouc, scarcely even swelling u immersed in sulphide of carbon. (For a full account of the manufacture an caoutchouc, both ordinary and vulcanised, see *Ure's Dictionary of Arts, Man and Mines*, i. 581—604. *Muspratt's Chemistry*, p. 441—451. Payen, *P Chimie Industrielle*, 4^{me} éd. i. 139—184. *Handw. d. Chem.* 2^{te} Aufl. ii. [2] 83

CAOUTCHOUC, MINERAL. See Elaterite.

CAOUTCHOUCIN. Empyreumatic oil of caoutchouc (p. 739).

CAPERS. See Capparis.

CAPHOPICRITE. Syn. of Rhein or Rhabarbarin.

CAPILLARITY. The surface of a liquid at rest is horizontal, exceptin it comes in contact with the sides of the vessel; there it is curved, being conca liquid wets the vessel, convex in the contrary case. Moreover, if one end of a tube be dropped into the liquid, the level of the liquid within the tube is not t as that without, but higher if the liquid wets the vessel and assumes a concave lower if it does not wet the vessel and forms a convex surface; thus water, ether, oils, &c., rise in narrow tubes of glass, metal, or wood, having the inne clean; but if the surface is greased so that the liquid cannot wet it, depressi place instead of elevation: mercury is also depressed in tubes of glass, but r tin tube, to which it can adhere. The phenomenon is called capillarit *capilla*, a hair), because it is most conspicuous in tubes of very fine bore. The however, extended to all the alterations of level and form of surface which ta at the contact of liquids and solids. The curved surface of the liquid wi tube is called a meniscus.

The amount of elevation of a liquid in capillary tubes is measured by rea with the cathetometer (a telescope moving up and down a vertical scale, p. 274), height of the lowest point of the meniscus, then the height of a fine metallic point exactly in contact with the surface of the liquid. In making this last observa point is brought down to the surface of the liquid, till it exactly coincides wit flected image therein, and a small quantity of the liquid is then removed with so as to leave the extremity free. Another mode of observation, adopted ch measuring the depression of mercury in glass tubes, is to place the liquid in a tube one arm of which is of capillary bore, while the other is wide enough t the alteration of level due to capillarity imperceptible. The difference of lev two arms is then read off with the cathetometer.

By these methods it has been found that the elevation or depression of li capillary tubes is regulated by the following laws:

1. In a tube of given diameter, the amount of elevation or depression depends nature of the liquid, and not at all upon the nature or the thickness of the ma the tube, the nature of the tube merely determining whether the liquid shall be

cording as the tube is or is not wetted by it, but not affecting the

t of elevation or depression varies with the temperature, but not according law as the density. Thus Gay-Lussac found that in a tube of 1 milli- the heights to which alcohol rose varied with the temperature and ws:

ensity.	Temperature.	Height of Column.
8196	8° C.	12·18 mm.
8135	16 „	9·15 „
8595	10 „	12·01 „
9415	8 „	12·91 „

rrow cylindrical tubes, the amount of elevation or depression of a given ersely as the diameter of the tube.

ular space enclosed between a wide cylindrical tube, and a solid cylinder ls it, the height to which a liquid rises is *half* that to which it would ical tube whose diameter is equal to the thickness of the annular space. een two parallel flat plates, which may be regarded as cylinders of in- height to which a liquid rises is half that in a cylindrical tube whose l to the width between the plates.

g table shows the height, as determined by **Frankenheim** (Pogg. , to which different liquids rise in cylindrical tubes of 1 millimetre

	Specific Gravity.	Height in millim.		Specific Gravity.	Height in millim.
. . .	0·840	6·60	Water	0·997	14·67
. . .	0·871	6·33	Sulphide of carbon . . .	1·253	4·84
. . .	0·820	6·63	Trichloride of phosphorus .	1·45	3·75
. . .	0·827	6·52	Disulphide of chlorine . .	1·687	4·93
. . .	1·030	6·60	Trichloride of arsenic . .	2·18	4·07
. . .	0·655	5·72	Dichloride of tin . . .	—	2·50
. . .	0·800	5·73	Chloride of nitrogen . .	1·34	3·9
. . .	0·716	4·77	Bromine	3·0	4·5
. . .	1·093	6·05	Sulphur	2·14	5·8
. . .	0·749	5·61	Mercury	13·59	—4·6

ry of capillary phenomena, we must refer to works on physics (*vid. h der Physik und Meteorologie*, 1853, i. 97).

R. One of the constituents of beech-tar, first separated by **Reichen**- hem. i. 1). According to **Völckel** (Ann. Ch. Pharm. lxxxvi. 99), tained, together with creosote and another oil, in the portion of wood-tar in potash, and on distilling the alkaline-liquid, capnomor passes over of water. It is perhaps partly formed by the decomposition of the

rless oil, having a peculiar odour, rather lighter than water; boils d 208° C. Insoluble in pure water and in potash, but dissolves partially s likewise present. Contains 81·2 carbon and 7·8 hydrogen; perhaps issolves in strong sulphuric acid with red-purple colour; the solution y water and then contains a conjugated acid. Nitric acid converts it l oxalic acid and another crystalline substance.

ANITE. A silicate of calcium and aluminium found in several localities th in radiated laminæ and in crystals belonging to the monoclinic ge perfectly parallel to 0P and ∞P∞, easy also parallel to ∞P. It colour with nacreous lustre; transparent only in thin laminæ. Specific Hardness = 3·5. It splits easily into thin acicular fragments. It when heated in a tube; and melts with intumescence to a white enamel pipe. Dissolves easily in acids, with separation of gelatinous silica. According **erson**'s analysis (N. Edinb. Phil. J. xxxiv. 21), it contains 52·8 SiO^2, 1 Fe^2O^3, 11·3 $Ca''O$, 1·1 K^2O, 0·2 Na^2O, 0·4 $Mg''O$ and 13·1 H^2O eing nearly with the formula $Ca''O.Al^2O^3.4SiO^2 + 3aq$. It appears of Laumontite formed by weathering.

S SPINOSA. A shrub growing in the south of Europe, the root-bark to contain a neutral bitter principle of sharp irritating taste, and gin. The flower-buds pickled in salt and vinegar form **capers**. Dis- r they yield a distillate having an alliaceous odour. After they have th cold water, hot water extracts from them capric acid and a gelatinous substance of the pectin group. Capric acid is sometimes found deposited on th of the buds in white specks having the appearance of wax. (Rochleder anc

CAPRAL. A term applied sometimes to caproic, sometimes to capric (see those compounds).

CAPRAMIDE. *Caprinamide.* $C^{10}H^{21}NO = N.C^{10}H^{19}O.H^2$.—The primar of capric acid, produced by the action of strong ammonia, on an alcoholic sol caprate of ethyl. When purified by crystallisation from alcohol, it forms c shining crystalline scales, which have a silky lustre when dry, are insoluble i and in aqueous ammonia, but dissolve readily in alcohol. (Rowney, Ann. Ch. lxxix. 231.)

CAPRIC ACID. *Rutic Acid.* $C^{10}H^{20}O^2$. (Gm. xiv. 485.)—This acid discovered by Chevreul in the butter of cow's milk. It is contained in cocoa and in several kinds of fusel oil; it occurs among the products of the distil oleic acid and of choloïdic acid, and is also formed by the oxidation of oleic of oil of rue.

According to Rowney, it is obtained pure and in tolerable quantity from the which remains in the distillation of fusel oil, after the amylic alcohol has dist at 132° C. The caproic acid is present as caprate of amyl. When this resid composed by boiling with caustic potash, the amylic alcohol distils over, and the contains caprate of potassium. On the addition of hydrochloric acid, capric liberated as an oily mass, which is washed with water and dissolved in dil monia. The caprate of ammonium is mixed with chloride of barium, and soluble barium-salt which precipitates is filtered off, washed with cold, and dis boiling water: on cooling, caprate of barium is deposited almost pure. To ob acid, this salt is treated with carbonate of sodium, and the solution of ca sodium is filtered from the carbonate of barium, then decomposed with sulphu which throws down capric acid almost colourless, and in the solid form. It is by solution in alcohol and reprecipitation by water.

The CAPRATES are mostly difficultly soluble in water.

Caprate of Barium, $Ba''(C^{10}H^{19}O^2)^2$, is almost insoluble in cold, but so boiling water, from which it separates in needle-shaped or large prismatic which float on water if not moistened.

Caprate of Calcium, $Ca''(C^{10}H^{19}O^2)^2$, falls as a white insoluble powd caprate of ammonium is mixed with chloride of calcium. It is more difficultl in boiling water than the barium-salt, and crystallises in beautiful lustrous la

Caprate of Magnesium resembles the calcium-salt.

Caprate of Lead is precipitated as a white amorphous powder when ca sodium is mixed with acetate of lead. It is very little soluble in boiling alco

Caprate of Silver is precipitated on the addition of nitrate of silver to ca ammonium. It is but slightly soluble in boiling water, and is deposited on c needle-shaped crystals. When moist, it is readily changed by exposure to lig

Caprate of Sodium is readily soluble in water and alcohol. On evapora obtained as a horny mass, presenting traces of crystallisation. It is easily so hot absolute alcohol, forming an opalescent mass.

Caprate of Ethyl. Capric ether, $C^{10}H^{19}(C^2H^5)O^2$, is formed by dissolvin acid in absolute alcohol, saturating the solution with dry hydrochloric acid then mixing with water. It separates as an oily layer, which, when was water, forms a colourless liquid of specific gravity 0·862.

CAPRIC ALDEHYDE. $C^{10}H^{20}O$.—The aldehyde of capric acid has been obtained with certainty. It was formerly supposed, according to the r Gerhardt (Ann. Ch. Phys. [3] xxiv. 96) and Wagner (J. pr. Chem. xlvi. 155 to be the chief constituent of oil of rue, but according to Gr. Williams (Phi 1858, p. 199), this oil consists mainly of *euodic aldehyde*, $C^{11}H^{22}O$. This resu as regards the quantitative constitution, has been confirmed by Hallwachs (Pharm. cxiii. 107), who, however, maintains that the body $C^{11}H^{22}O$ is not an a According to more recent statements by Wagner, on the contrary, oil of rue capric aldehyde, and forms with ammonia a compound which, when treated w phydric acid, yields *thiocapric aldehyde*, $C^{30}H^{61}S^2N$, and with hydrochloric and cyanic acid a compound homologous with alanine. (See **RUE, OIL OF.**) (H Chem. 2te Aufl. ii. [2] 741.)

CAPRINAMIDE. See CAPRAMIDE.

CAPROCIANITE. Syn. with CAPORCIANITE.

CAPROENE. Syn. with HEXYLENE, C^6H^{12}.

ACID. $C^6H^{12}O^2$. (Gm. xi. 414.)—This acid, the sixth in the series
vas first discovered by Chevreul in the butter of cow's milk, in which it
nation with glycerin. It exists in considerable quantity in cocoa-nut
se, and is a not unfrequent product of the oxidation of the fatty acids of
weight; it is also obtained by the oxidation of poppy oil and of casein.
nut oil it is readily obtained by saponification with soda-ley of spe-
2. The soap is decomposed by sulphuric acid, and rapidly distilled
etort. The distillate, which consists essentially of caproic and caprylic
lised with baryta, and the solution evaporated to crystallisation. The
first form are caprylate of barium; when the solution is further evapo-
ed to stand, caproate of barium is obtained in verrucose crystals. The
crystallisation and decomposed by a stronger acid, yields caproic acid

hod of preparation is that of Frankland of Kolbe, viz. the decomposi
of amyl by potash:

$$\underset{\text{Cyanide of amyl.}}{C^6H^{11}N} + KHO + H^2O = \underset{\text{Caproate of potassium.}}{C^6H^{11}KO^2} + \underset{\text{Ammonia.}}{NH^3}.$$

modified by Wurtz, is as follows:—To prepare cyanide of amyl,
obtained by calcining ferrocyanide of potassium in a covered cru-
in a retort connected with the lower part of a Liebig's condenser,
ur or five times its weight of alcohol, and the mixture is heated to boil-
y of iodide of amyl, not quite sufficient to decompose the cyanide, is
introduced through a funnel-tube, and the boiling is continued till the
is complete. This point is ascertained by allowing a drop of the oil
on the addition of water, to evaporate on the end of a glass rod held in
resence of the smallest quantity of iodide is perceptible by the brown
ne produced. When the conversion of the iodide is effected, the alco-
nixed with excess of water, and the oil which separates is boiled with
on of potash in a retort connected with the lower end of a Liebig's
it is completely decomposed into ammonia and caproic acid. The ca-
ium is then decomposed by a stronger acid, and the oily layer removed

is a clear mobile oil of specific gravity 0·931 at 15° C. It has a sudo-
penetrating acid taste. Sparingly soluble in water, but dissolves
bsolute alcohol. The acid prepared from cyanide of amyl solidifies at
ils at 198°, and according to Wurtz, has the property of circular pola-
from cocoa-nut oil boils between 202° and 209° (probably owing to an
prylic acid), and does not affect the plane of polarisation.
is dissolved by sulphuric acid without change in the cold, and is again
e addition of water. A concentrated solution of caproate of potassium,
to a current from six of Bunsen's elements, is electrolysed in a manner
lerate of potassium. The oil which separates on the surface contains
gether with another body, which is probably caproate of amyl, result-
ndary decomposition:

$$\underset{\text{Caproate of potassium.}}{2C^6H^{11}KO^2} + O = \underset{\text{Amyl.}}{C^{10}H^{22}} + \underset{\text{Carbonate of potassium.}}{K^2CO^3} + CO^2.$$

r $$\underset{\text{Caproate of potassium.}}{2C^6H^{11}KO^2} + O + H^2O = \underset{\text{Amyl.}}{C^{10}H^{22}} + \underset{\text{Acid carbonate of potassium.}}{2KHCO^3}.$$

-The salts of capric acid resemble the valerates, and are obtained in a

f *Ammonium*, obtained by saturating caproic acid with ammoniacal
line salt, which, by absorbing more ammonia, again deliquesces.

f *Barium* is obtained by saturating the acid with carbonate of barium.
evaporation of the solution below 18° C. it crystallises in lustrous
næ, which become milky in the air. Crystallised above 30° C. it forms
some length. It dissolves in 12·5 pts. of water at 20° C. In moist
caproic acid, and its aqueous solution deposits a basic salt when boiled.
it yields combustible gases, among which propylene, C^3H^6, is present
ntity, and an oil passes over which contains propione, $C^{11}H^{22}O$. The
of carbonate of barium and charcoal.

f *Calcium* forms lustrous square laminæ, which are soluble in 49 pts.
° C., and fuse on being heated, emitting an odour like that of the

Caproate of Magnesium, $Mg''(C^6H^{11}O^2)^2$ + 2 aq., crystallises in smal
gated needles, which retain 1 at. of water when heated above 100° C.

Caproate of Potassium, $C^6H^{11}KO^2$, is obtained by the spontaneous eva
of its solution, as a transparent jelly, which becomes opaque when warmed.

Caproate of Silver, $C^6H^{11}AgO^2$, is obtained by precipitating an aqueous
of the barium-salt with nitrate of silver, as a white precipitate, sparingly so
cold water. After being washed out with cold, and then dissolved in boiling
separates on cooling in magnificent crystalline laminæ, which are unaltered by

Caproate of Sodium, $C^6H^{11}NaO^2$, resembles the potassium-compoun
aqueous solution forms a white uncrystalline mass on evaporation.

Caproate of Strontium, $Sr''(C^6H^{11}O^2)^2$, crystallises in transparent
which effloresce in the air.

CAPROIC ALCOHOL. See Hexylic Alcohol.

CAPROIC ALDEHYDE. *Hydride of Caproyl.* $C^6H^{12}O = C^6H^{11}O.H.$
compound appears to be produced in small quantity in the dry distillation of cap
calcium or barium, being found chiefly in the first portion of the distillate obta
the rectification of crude caprone. (Brazier and Gossleth, Ann. Ch. Pharm. lx

CAPROIC ANHYDRIDE or *Anhydrous Caproic Acid.* $C^{12}H^{22}O^3 = (C^6H$
—According to Chiozza, this body is prepared by placing 6 at. caproate of ba
a retort, and gradually adding 1 at. oxychloride of phosphorus. The mass
warm and pasty; on cooling it is extracted with pure ether; the ethereal
is agitated with weak potash, then dried over chloride of calcium; and finally t
is evaporated in the water-bath.

Caproic anhydride is a neutral oil, lighter than water, and with an odour re
caproic acid. When heated it volatilises, emitting an aromatic odour, and le
slight carbonaceous residue.

CAPROIC ETHERS. *Caproate of Methyl*, $C^6H^{11}(CH^3)O^2$, is obtained,
ing to Fehling, by mixing 2 pts. each of caproic acid and of wood-spirit with
sulphuric acid, and gently heating the mixture. The liquid is mixed with wa
the supernatant oil is washed with water and dried over chloride of calcium
a colourless liquid of specific gravity 0·8977 at 18° C.; boils at 150° C. Its
density is 4·623.

Caproate of Ethyl, $C^6H^{11}(C^2H^5)O^2$, is obtained like the preceding compound
a transparent liquid, with a pine-apple odour, somewhat resembling butyric e
not so delicate. Its specific gravity is 0·882 at 18° C., and it boils at 162° C.
pour-density is 4·97.

Caproate of Amyl. $C^6H^{11}(C^5H^{11})O^2$.—Crude caproic acid (prepared by Fr
and Kolbe's method), the greater part of which passes over at 198° C., contain
mixture of caproate of amyl. On continuing the distillation, it passes over at
It may also be obtained by neutralising the crude acid with carbonate of pot
whereupon it remains undissolved as an oily layer. Removed, dried over chl
calcium, and rectified, it is obtained pure, and of constant boiling point at 211
is insoluble in water, but soluble in all proportions in alcohol and ether. It is
posed by potash into caproate of potassium and amylic alcohol.

CAPRONE. $C^{11}H^{22}O$? When caproate of barium is submitted to destruct
tillation, tritylene and other gases are given off, and a colourless oil passes o
this oil be dried and rectified, it begins to boil at 120° C., and the thermomet
mately rises to 160°–170° C. By rectification, a product is obtained, boili
stantly at 165° C. It is a colourless oil, lighter than and insoluble in water, and
a peculiar odour. It is readily soluble in alcohol and ether, becomes brown in
and is attacked by nitric acid even in the cold, *nitrovaleric acid*, $C^5H^9(NO^2)O$
apparently formed.

The boiling-point of this compound (164° C.), differs widely from that calcula
caprone, 232°, and it is hence doubtful whether it is the true caprone.

CAPRONITRILE. $C^6H^{11}N$. This compound, which contains the elem
caproate of ammonium *minus* water $[C^6H^{11}(NH^4)O^2 - 2H^2O]$, has not been o
directly from that salt. The isomeric (or identical) compound, cyanide of
$C^5H^{11}.CN$, is obtained by heating an alcoholic solution of iodide of amyl
boiling point, with excess of cyanide of potassium. (See Cyanides of Al
Radicles.)

CAPRONOYL. A name applied by Weltzien to the radicle C^6H^{11}, which
supposed to exist in caproic aldehyde, $C^6H^{11}.H.O.$ and in caprone, $C^6H^{11}.C^5H^{11}.$

CAPROYL (or *Capronyl*, according to Weltzien), $C^6H^{11}O$.—The radicle of
acid and its derivatives: *e. g.* caproic acid = $C^6H^{11}O.H.O$; caproic aldehyde, C^6H

$^5H^{11}$, &c. The same term is also sometimes applied to the corre-
adicle C^6H^{13}; but it is much better to designate this radicle by the
proposed by Gerhardt. (See Hexyl.)

MINE. See Hexylamine.

NE. See Hexylene.

RUTYL, $C^{10}H^{19}O$. — The radicle of capric or rutic acid,
its derivatives. The same term is applied to $C^8H^{15}O$, the radicle
it is better however to call the latter caprylyl, unless indeed the
e altogether abandoned, and rutic acid substituted for it. $C^{10}H^{19}O$
led rutyl, and $C^8H^{15}O$, capryl. There is at present great confusion
s of these radicles, which is further increased by the application of
apryl, to C^8H^{17}, the radicle of the 8-carbon alcohol. For this last-
we shall use Gerhardt's name Octyl (*q. v.*)

INE. See Octylamine.

E. See Octylene.

ACID. $C^8H^{16}O^2 = C^8H^{15}O.H.O$ (Gm. xiii. 190).—Caprylic acid was
ch, in the butter of cow's milk. It is also contained in cocoa-nut oil
heese; in several kinds of fusel oil it occurs partly free and partly
th ethyl and amyl.

e for this acid is cocoa-nut oil: from the difficult solubility of its
easily separated from caproic acid, with which it is associated (see
The caprylate of barium is purified by recrystallisation; its aqueous
ed by sulphuric acid; and the oily liquid which rises to the surface
tilled: the distillate between 230 and 238° C. is pure caprylic acid.
as a feeble but unpleasant odour, which is more perceptible when
It solidifies at 12° C., melts at 15°, and as the liquid slowly cools,
g cholesterin form in it. At 20°, its specific gravity is 0·911. It
8°; its observed vapour density is 5·31 (calculated 4·98).
is monobasic, the general formula of its salts being $C^8H^{15}MO^2$.
um, $Ba''(C^8H^{15}O)^2$, crystallises from a hot aqueous solution, in fine,
æ; by spontaneous evaporation, in small white grains. It dissolves
t 100°C., and in 126 pts. at 10°. It is quite insoluble in alcohol and
s no water of crystallisation, and can be heated to 100° without

ad, $Pb''(C^8H^{15}O^2)^2$, is obtained on mixing caprylate of barium with
ls a sparingly soluble precipitate, which melts at 100° C.
lver, prepared in the same manner, is white and insoluble. E. A.

Substitution-derivative of Caprylic Acid.

Acid. $C^8H^{15}NO^4 = C^8H^{15}(NO^2)O^2$ (Wirz, Ann. Ch. Pharm. civ.
s produced by the continued action of nitric acid at the boiling heat on
n-volatile fatty acids which is obtained from cocoa-nut oil by saponify-
oda, decomposing the soap with sulphuric acid, and distilling off the
fter washing the product with hot water, till the grains of suberic acid
removed, there remains a heavy oil, containing nothing but nitroca-
pric acids. The acid thus obtained is a yellowish-red, syrupy oil, hav-
our and bitter taste, of specific gravity 1·093, at 18° C.; it dissolves
r, more easily in strong nitric acid. When heated, it becomes dark-
omposes, with evolution of nitrous acid, and at a higher temperature,
.

cid neutralises alkalis completely. With ammonia, it forms a yel-
with potash a deep red solution, leaving an uncrystallisable mass
. The ammonia-salt yields with salts of calcium, barium, lead, and
ipitates, which form a viscid mass when stirred. The silver-salt,
is precipitated in yellowish-white flakes, which dry up to a yellowish-

ALCOHOL. See Octylic Alcohol.

ALDEHYDE. *Hydride of Caprylyl*, $C^8H^{16}O = C^8H^{15}O.H.$—A body
osition and capable of uniting with the acid sulphites of alkali-metals,
g other products, by the dry distillation of castor-oil soap (ricinoleate
ssium), either alone or with excess of alkali. It was first obtained
Ann. Ch. Pharm. xciii. 242), who regards it as caprylic aldehyde;
ned by Bouis (Ann. Ch. Phys. [3] xlviii. 99), who takes the same
itution; and further by Städeler (J. pr. Chem. lxxii. 241), and by

Dachauer (Ann. Ch. Pharm. cvi. 270), who regard it as an acetone, vi
œnanthyl, $CH^3.C^7H^{13}O$. According to Bouis, the aldehyde is formed, to
an acid ($C^{10}H^{18}O^2$), and without evolution of gas, chiefly when castor-oil so
heated to a temperature not exceeding 225°—230° C., and without excess

$$\underset{\text{Ricinoleic acid.}}{C^{18}H^{34}O^3} = \underset{\text{Caprylic aldehyde.}}{C^8H^{16}O} + \underset{\text{New acid.}}{C^{10}H^{18}O^2};$$

whereas if the soap be quickly and strongly heated, especially with exce
hydrogen is abundantly evolved, and octylic alcohol is produced, together
acid (see page 98). Malaguti obtained sometimes octylic alcohol, sometin
aldehyde, but always sebacic acid; he explains the formation of these prod
equations:

$$\underset{\text{Ricinoleic acid.}}{C^{18}H^{34}O^3} + H^2O + O = \underset{\text{Octylic alcohol.}}{C^8H^{18}O} + \underset{\text{Sebacic acid.}}{C^{10}H^{18}O^4}$$

$$C^{18}H^{34}O^3 + O^2 = \underset{\text{Caprylic aldehyde.}}{C^8H^{16}O} + C^{10}H^{18}O^4$$

Städeler and Dachauer likewise obtained sebacic acid in every case (p. 98
Caprylic aldehyde is also produced by distilling a mixture of caprylate
of calcium (**Limpricht**):

$$\left.\begin{matrix} C^8H^{15}O \\ \frac{1}{2}Ca'' \end{matrix}\right\}O + \left.\begin{matrix} CHO \\ \frac{1}{2}Ca'' \end{matrix}\right\}O = Ca''CO^3 + \left.\begin{matrix} C^8H^{15}O \\ H \end{matrix}\right\}$$

To prepare pure caprylic aldehyde, the crude distillate obtained by hea
oil soap with excess of hydrate of potassium, is treated with a strong aque
of acid sulphite of sodium; and the resulting crystalline mass is repeat
between paper, washed with alcohol, dried over sulphuric acid, and diss
water, whereby it is decomposed, and caprylic aldehyde set free: it is the
chloride of calcium and rectified. According to Bouis, it is better to distil
soap *per se*, or better still, the barium-salt formed from it, because the lat
froth.

Caprylic aldehyde is a colourless, strongly refracting liquid, having
odour and caustic taste. Specific gravity 0·818 at 19° C. (**Bouis**). B
178° (**Limpricht**); 171° under ordinary pressure (**Bouis**). It is insolu
It burns with a bright non-smoking flame; becomes acid when warm air
passed through it (**Bouis**); and is violently oxidised by nitric acid, wit
of caprylic acid and other fatty acids; chromic acid also partly convert
acid. Heated with solid potash, it forms a brown spongy mass. With
nitrate of silver it forms a metallic mirror. With pentachloride of phospho
chloride of octylene, $C^8H^{16}Cl^2$.

Caprylic aldehyde unites with acid sulphites of alkali-metals, without r
rature. The compounds are insoluble in excess of the acid sulphite, and
posed by water. The sodium-salt contains $2C^8H^{16}O.2NaSO^3.SO^2 + 2aq$.

CAPRYLIC ANHYDRIDE. *Anhydrous Caprylic acid*, $C^{16}H^{30}O^3$. =
—This body is obtained by treating 6 at. caprylate of barium with 1 at. of
of phosphorus. Much heat is disengaged, and the mixture is changed
mass, developing a peculiar and unpleasant odour, which probably arises f
of caprylyl. From this pasty mass, the anhydride is extracted by tre
ether, which must be free from alcohol. The ethereal solution is agitated
potash-ley, in order to remove caprylic acid, and then dried over chlorid
On the evaporation of the ethereal solution, the anhydride is left as a clea
lighter than water. When freshly prepared, it has a sickly odour, wh
evident when it begins to pass into caprylic acid. When heated, it gives
which attack the throat, but have an aromatic odour. In a freezing
solidifies to a white mass of imperfectly crystalline texture. It begin
280° C., the temperature gradually increasing to 290°, when the liquid
compose. Boiling water does not convert it into caprylic acid, but when
time in contact with moist air, it gradually changes into that substance.
gradually changes it into caprylic acid. (**Chiozza**, Ann. Ch. Pharm. lxx

CAPRYLIC ETHERS. *Caprylate of Methyl.* $C^8H^{15}(CH^3)O^2$,
when caprylic acid dissolved in its own weight of methylic alcohol is m
quarter of the weight of sulphuric acid. The liquid immediately becomes
the caprylate of methyl forms a light oily layer on the surface. It is remo
with water, and dried. It is a colourless, highly aromatic liquid, with
wood-spirit. Its specific gravity is 0·882, and vapour-density 5·48. It
soluble in water, but dissolves readily in alcohol and in ether. (**Fehli**
Pharm. liii. 405.)

hyl, $C^8H^{15}(C^2H^5)O^2$, is prepared like the preceding compound.
id, with a pine-apple odour. Its specific gravity is 0·8738 at 15°.
Vapour-density = 6·1. It is insoluble in water, but soluble in
Fehling). E. A.

This name has been given to a substance which Guckelberger
ructive distillation of caprylate of barium, in quantities of about
excess of lime. White vapours pass off, and condense in the re-
y liquid, which after some time solidifies to a yellow buttery mass.
ication, it is obtained as a white crystalline body, like Chinese
axy odour. It is very soluble in alcohol and ether, whether hot
40° C., and solidifies at 38° to a radiating crystalline mass. It
stils without alteration.
of caprylone, as calculated from that of its homologue œnanthylone,
he discrepancy between this number and 178°, the boiling-point
to prove that this is not the true acetone. Further experiments
de the point. E. A.

$C^8H^{15}O$. The radicle of caprylic acid, &c.

URSA PASTORIS. *Shepherd's Purse.*—The green parts of
acrid sulphuretted volatile oil (oil of mustard?) waxy and fatty
nin, tartaric, citric, and malic acids, colouring matter, and traces
of the air-dried herb yielded 9 per cent. of ash containing sand,
which, in 100 pts., after deducting the charcoal, was found to be:
, 14·7 CaO, 3·1 MgO, 1·9 Fe^2O^3, 0·1 Al^2O^3, 16·2 CO^2, 6·2 SO^3,
6 SiO^2 and sand. (Daubrawa, Repert. Pharm. xcix. **127**.)
by distillation with water, a volatile oil, which, according to Pless,
l of mustard. According to G. J. Mulder, the seed contains in
oil, 26·5 albumin, 12·3 non-nitrogenous soluble matter, 16·0 woody
d 4·8 ash. According to Neuburger, the seed contains 20 per cent.
umin. (Handw. d. Chem. 2^te^ Aufl. ii. [2] 780.)

An alkaloïd obtained from Spanish pepper, the fruit of *Capsicum*
not, Ann. Ch. Phys. [2] vi. 1; Witting, Buchner's Repert. xxxvi.
ierteljahrs. pr. Pharm. iii. 34.) The same name is applied in
resinous extract from Cayenne pepper (*Capsicum baccatum*).

TUUM. An old term for the residue of a distillation or subli-
npure ferric oxide obtained as a residue in the distillation of fuming
ferrous sulphate. was called *Caput mortuum vitrioli.*

MOSS. *Irish pearl moss.* (*Sphæroccus crispus.*)—An alga,
on the coasts of the Atlantic and the North Sea. It is used as
n chest complaints, and for the clarification of turbid liquids. It
ably in cold water, and dissolves almost wholly on boiling. The
cooling, a jelly having a faint saline taste, and the peculiar odour
rding to Herberger, it contains 79·1 per cent. gelatinous matter,
cold water, perfectly in hot water, insoluble in alcohol and ether;
e in water, alcohol, and ether; 0·7 resin; 1·3 chloride of sodium;
nesium; 8·7 skeleton, consisting of cellular substance and salts.
midt (Ann. Ch. Pharm. li. 56), the mucus obtained by precipitating
tion with alcohol containing hydrochloric acid, pressing the pre-
ng it with alcohol, contains 44·8 carbon to 6·2 hydrogen, (whence it
drate of carbon, like sugar, starch, &c.,) and leaves, when burnt,
chiefly consisting of sulphate of calcium. The skeleton of caragheen
cineration an ash containing sulphate and phosphate of calcium,
arphati, likewise metallic iodides. (Handw. d. Chem. 2^te^ Aufl. ii.

CRAJURU, or **CARCURU.** A red dye-stuff, imported from
bably identical with *chica-red*, which is obtained from the leaves of
. Carajuru appears, however, to be superior to ordinary chica, and
ished from it by greater purity. According to Virey (J. Pharm.
a light mealy powder, destitute of taste and smell, and acquiring a
rituration. It is insoluble in water, soluble in alcohol, ether, and
tated from the latter by acids in its original state. Burns with
nsiderable quantity of ash.

(Péligot, Ann. Ch. Phys. lxvii. 172.—Gélis, Ann. Ch. Phys. [3]
ct of the action of heat upon sugar. When cane-sugar is heated in
h to between 210° and 220° C., care being taken not to exceed the
, it assumes a brown colour of continually increasing depth, without

giving off any permanent gas; vapour of water is, however, evolved, contai
of acetic acid and an oily substance. When the tumefaction has ceased,
is found to contain a black substance, which dissolves completely in wat
caramel. To obtain it pure, it is dissolved in a small quantity of water and p
by alcohol. It may also be obtained from glucose, but not so readily.

Caramel when pure is insipid; its aqueous solution has a rich sepia tint.
soluble in alcohol; does not ferment under the influence of yeast; it yie
precipitates with ammoniacal acetate of lead and baryta-water. When stron
it yields the same products as sugar. (Péligot.)

Caramel was long regarded as a simple proximate principle of the formul
the precipitate which it forms with baryta-water having the composition C
But, according to Gélis, caramel prepared as above is a mixture of severa
substances, some soluble, others insoluble in water, amongst which he parti
tinguishes three, viz. *caramelane*, $C^{12}H^{18}O^{9}$, *caramelene*, $C^{36}H^{50}O^{25}$, and
$C^{96}H^{102}O^{51}$. All these substances are produced from sugar by elimination
ments of water, the atomic weight being at the same time increased, thus:

$$\underset{\text{Sugar.}}{8C^{12}H^{22}O^{11}} - 37H^{2}O = \underset{\text{Caramelin.}}{C^{96}H^{102}O^{51}};$$

and by keeping sugar for some time at 190° C. these products may be ob
after the other. If crystallised cane-sugar be used, the residue, after 10 p
been given off as water, consists of nearly pure caramelane; after 14 or
has gone off, the residue is rich in caramelene; and after a loss of 20
consists almost wholly of caramelin. Grape-sugar yields products nearly
but not identical with these.

Caramelane may also be obtained pure by digesting ordinary caram
per cent. alcohol, which sometimes dissolves it completely, sometimes leave
amounting to 40 per cent; treating the solution (which contains carame
composed sugar, and sometimes a little caramelene) with yeast to decompos
by fermentation; evaporating the filtrate to dryness; redissolving in alc
then leaves the caramelene undissolved; and evaporating the solution.

Caramelane, to which ordinary caramel chiefly owes its characteristic p
a brown substance, hard and brittle at ordinary temperatures, very soft
odourless, with a strong bitter taste, deliquescent, very soluble in water,
soluble in aqueous alcohol, sparingly in absolute alcohol, insoluble in ether.
cupric oxide in alkaline solution, also gold and silver from their salts.
converts it into oxalic acid. The aqueous solution does not precipitate me
The alcoholic solution forms, with an alcoholic solution of neutral acetat
yellow precipitate containing $C^{12}H^{16}Pb''O^{9}$; with an ammoniacal solution
lead, added in sufficient quantity to produce complete precipitation, it
compound $C^{12}H^{16}Pb''O^{9}.Pb''O$; and with excess of a solution of baryta in
a precipitate containing $C^{12}H^{16}Ba''O^{9}.Ba''O$. At 190° C. caramelane gives o
passes into caramelene (Gélis). Völckel (Ann. Ch. Pharm. lxxxv. 59)
term *caramelane* to the black residue, insoluble in water, left on heatin
250°—300° C. This residue is insoluble in alcohol, sparingly soluble in
has, according to Völckel, the composition $C^{24}H^{26}O^{13}$. It is perhaps identic
substance here called caramelin.

Caramelene. $C^{36}H^{50}O^{25}$.—The residue left after treating caramel with
84 per cent. contains caramelene, which may be extracted by cold water,
rated from the solution by evaporation or by precipitation with absolute
freed from a small quantity of admixed caramelin by redissolving it in w
solid and brittle, of the colour of mahogany, not hygroscopic, easily solub
(exhibiting a colouring power six times as great as that of caramelane) an
alcohol, sparingly in strong alcohol, and insoluble in ether. It reduces c
from an alkaline solution, and is converted by nitric acid into oxalic acid.
compound, precipitated by alcohol, is composed of $C^{36}H^{48}Ba''O^{25}$. With le
the three compounds $C^{36}H^{48}Pb''O^{25}$, $C^{36}H^{48}Pb''O^{25}.3Pb''O$, and $C^{36}H^{46}Pb''O^{25}$

Caramelin, $C^{96}H^{102}O^{51}$, exhibits three isomeric modifications, viz. *A*,
water; *B*, insoluble in water, soluble in other liquids; *C*, insoluble in a
solvents. The modifications *B* and *C* are contained in the residues left aft
caramel with cold water; and from these residues *B* may be extracted
water (*B* then passing into *A*) by 60 per cent. alcohol, or by alkaline liqui
melin separates from a hot aqueous solution on evaporation in films, by pr
with alcohol as a copious precipitate, but in both cases as the modification *B*
when precipitated by acids from alkaline solutions. But when caramelin
or even left for several days in the moist state, it passes into the modificat
is then insoluble in all solvents. Caramelin *B*, which is insoluble in cold wa

lves in a mixture of those two liquids. Its colouring power is 12
at of caramelane.
ack, shining, infusible substance. Like caramelane, it reduces gold
r solutions, and cupric oxide in its alkaline solution. Its solution
early all metallic salts. It forms the compounds $C^{96}H^{100}Ba''O^{51}$,
, and $C^{76}H^{100}Pb''O^{51}$. (Gélis.)
pt. rend. xxxix. 422) designates by the name caramelin a black-
$^{12}H^{8}O^{4}$, insoluble in water, acids and alkalis, obtained by mixing 1 pt.
30 pts. dichloride of tin, evaporating to dryness, and heating for a
°—130° C.; also by similar treatment of glucose, cellulose, dextrin,
of carbon of similar constitution. Völckel's caramelane (p. 748) is
as Gélis's caramelin.
A resin obtained from the *Bursera gummifera*. It is sent into the
apped in leaves; is grey-black outside, dark brown within; has a
brittle and easily powdered. It melts when heated, emitting an
as a bitterish taste. It resembles resin of guaiac in some respects,
e in repute among the Germans for smoking in pipes, as a remedy
d oil of caranna was also prescribed for a like purpose. It is now

RK. The bark of a tree indigenous in Guiana and Hispaniola,
anensis, *Personia guarcoides*, and *Xylocarpus Carapa*. It has a
at of cinchona bark, and is used in intermittent fevers. It is said
cid, a red colouring matter, and an organic alkaloïd called cara-
crystalline salts with hydrochloric and acetic acids. (Petroz and
m. vii. 293, 349.)
same tree, which is beautifully veined, is much prized for furniture.
rapa tulucana, Caventou (J. Pharm. xxxv. 189) found one yellow
nd a bitter principle, which he calls tulucunin.
Carapa molucensis exudes a whitish powder when wounded; it is
nt, and is said to be used as a remedy against cholera and biliary

L. A bitter fat oil, obtained by pressure in the heat of the sun
Carapa guianensis and *C. tulucana*. It is used by the Indians
kin against the punctures of insects. It solidifies at + 4° C. and
lves sparingly in alcohol, easily in ether; is saponified by alkalis.
aid to be due to strychnine, and to be removed by sulphuric acid.
further pressure, assisted by heat, a fat which melts at 40°—50° C.
v. 49.—Bouillay, *ibid.* vii. 293.)
arbitrary weight by which gold and gems are weighed or estimated.
is equal to 4 grains whereof 612 are contained in the troy ounce; in
oy ounce contains 153 diamond carats or 612 diamond-grains.
expressing the fineness of gold, the whole mass is supposed to
12 grs. each, either real or merely proportional, like the assayer's
ure gold is called fine. Thus, if gold is said to be 23 carats fine, it
that in a mass weighing 24 carats, the quantity of pure gold is 23
U.

ACID. $CH^{3}NO^{2} = \left.\begin{matrix}NH^{2}(CO)''\\ H\end{matrix}\right\}O$.—This acid is not known in the
ave any of its metallic salts, properly so-called, been obtained. Its
$^{2}H^{6}CO^{2} = \left.\begin{matrix}NH^{2}(CO)''\\ NH^{4}\end{matrix}\right\}O$, is the so-called *anhydrous carbonate of*
s compounds with alcohol-radicles constitute the class of bodies
e.g. carbamate of ethyl or ethyl-urethane, $C^{3}H^{7}NO^{2} = \left.\begin{matrix}NH^{2}(CO)''\\ C^{2}H^{5}\end{matrix}\right\}O$.
t also be regarded empirically as compounds of carbonic anhydride
ding alcohol-bases: *e.g.* ethylurethane as $CO^{2} + C^{2}H^{7}N$ (ethyl-
formation and properties do not accord with this latter view.
e produced, together with sal-ammoniac, by the action of ammonia
rbonates of the alcohol-radicles:

$$\underset{\substack{\text{Chlorocar-}\\ \text{bonate of}\\ \text{ethyl.}}}{C^{2}H^{5}.CO^{2}Cl} + 2NH^{3} = NH^{4}Cl + \underset{\text{Ethyl-urethane.}}{C^{2}H^{5}.CH^{2}NO^{2}}$$

anhydrous ammonia on the corresponding carbonic ethers:

$$\underset{\substack{\text{Carbonate}\\ \text{ethyl.}}}{\left.\begin{matrix}(CO)''\\ (C^{2}H^{5})^{2}\end{matrix}\right\}O} + NH^{3} = \underset{\substack{\text{Carbamate of}\\ \text{ethyl.}}}{\left.\begin{matrix}NH^{2}(CO)''\\ C^{2}H^{5}\end{matrix}\right\}O} + \underset{\text{Alcohol.}}{C^{2}H^{5}.H.O.}$$

3. By the action of chloride of cyanogen on the alcohols:

$$C^2H^5.H.O + CN.Cl + H^2O = \left.\begin{matrix} NH^2(CO)'' \\ C^2H^5 \end{matrix}\right\} O + HCl$$

Carbamic acid in which the whole of the oxygen is replaced by sulphur
sulphocarbamic acid, CH^3NS^2 (*q. v.*)

There is also an oxysulphocarbamic acid, the ethyl- and amyl-sa
have been obtained, viz. xanthamide, $\left.\begin{matrix} NH^2(CO)'' \\ C^2H^5 \end{matrix}\right\} S$, and xantha
$\left.\begin{matrix} NH^2(CO)'' \\ C^5H^{11} \end{matrix}\right\} S$. (See those articles; also page 206.)

Carbamate of Ammonium. *Anhydrous Carbonate of Ammonia.*
$\left.\begin{matrix} NH^2(CO)'' \\ NH^4 \end{matrix}\right\} O$.— This salt, which was discovered by H. Davy, and further
by J. Davy and H. Rose, is produced: 1. By passing a mixture of carboni
and ammonia-gas through a number of glass tubes cooled to a low temp
whatever proportion the gases may be mixed, they always unite in the p
2 vol. NH^3 to 1 vol. CO^2.—2. By subliming a mixture of carbonate of
sulphamate of ammonium, $N^2H^6SO^3$, both perfectly dry. (H. Rose.)

It is a white mass which smells of ammonia, has a strong alkaline reactio
a little above 60° C., and condenses again below 60°. The specific gravity
is 0·8992 (H. Rose), 0·90 (Bineau). Now 2 vols. ammonia + 1 vol.
1·1787 + 1·5252 = 2·7039, which is nearly three times the observed specif
the vapour. Hence the two gases appear to unite without condensation, alt
equal volumes. Probably the compound exists only in the solid state, an
by heat into CO^2 and $2NH^3$.

Vapour of sulphuric anhydride converts carbamate of ammonium into su
ammonium with evolution of carbonic anhydride. Heated in sulphurous a
yields an orange-coloured sublimate. Hydrochloric acid decomposes it
heat, yielding sal-ammoniac and carbonic anhydride.

Carbamate of ammonium dissolves readily in water, yielding a solution
the reactions of neutral carbonate of ammonium, from which, indeed, it differ
elements of water [$N^2H^6CO^2 = (N^2H^4)^2CO^3 - H^2O$]. It appears, however t
of existing in solution for a short time as carbamate; for on passing car
dride into aqueous ammonia, taking care that the liquid does not beco
resulting solution does not precipitate chloride of calcium or chloride of
after some time, unless the liquid be heated. This circumstance is of i
chemical analysis; thus, in determining the amount of carbonic acid in a m
by means of chloride of calcium and ammonia, it is necessary to leave t
stand for some time, or heat it to the boiling point, in order to insure tha
of the carbonic acid is precipitated as carbonate of calcium. (Kolbe.)

According to H. Rose, ordinary carbonate of ammonium prepared by
often contains carbamate. (Gm. ii. 430).

Carbamate of Amyl. *Amyl-urethane*, $C^6H^{13}NO^2 = CH^2(C^5H^{11})NO^2$.—
Ann. Ch. Pharm. lxxi. 104.—A. Wurtz, J. Pharm. [3] xx. 22).—Obtain
ammonia to amylic alcohol saturated with chlorocarbonic oxide, and wa
sulting crystalline mass with water to separate sal-ammoniac; or by pas
chloride of cyanogen into amylic alcohol and distilling, chloride of amyl
over first, and afterwards the carbamate.

This compound crystallises from boiling water in beautiful silky needle
alcohol and ether. It melts at 66° C. and distils without alteration at
tilled with caustic baryta, it yields ammonia and amylic alcohol, with a re
bonate of barium. It dissolves completely in cold sulphuric acid, and is
therefrom by water. Heated with sulphuric acid, it forms amyl-sulphu
ammonia, with evolution of carbonic and sulphurous anhydrides.

Carbamate of Ethyl. *Urethane.* $C^3H^7NO^2 = CH^2(C^2H^5)NO^2$. (Duma
Phys. liv. 233.— Cahours, Compt. rend. xxi. 629.—Liebig and Wöhle
Pharm. liv. 370.—Gerhardt, Compt. chim. 1846, p. 120.—Wurtz, C
xxii. 503, J. Pharm. [3] xx. 19) —This compound is prepared: 1. By leavi
of ethyl in contact with an equal volume of aqueous ammonia in a corked
completely disappears, and evaporating in a dry vacuum.—2. By treatin
bonate of ethyl with ammonia, and distilling: the action is very violent.
ordinary strength is saturated with gaseous chloride of cyanogen; the
heated for some hours in a sealed long-necked flask placed in a water-ba
liquid when cold is decanted from the deposit of sal-ammoniac arising from
action, and distilled. Chloride of ethyl then passes over first, then alcoh

(p. 749), after which, the temperature rises, and urethane passes over, condensing in laminæ.

Carbamate of ethyl forms large transparent colourless crystals: even a few drops of its solution left to evaporate are sure to yield these crystals. It melts below 100° C., and distils at about 180° without alteration if dry; but in the moist state it suffers partial decomposition, giving off torrents of ammonia. It dissolves readily in water, forming a solution which does not precipitate silver-salts; also in alcohol and ether. Its vapour-density, by experiment, is 3·14, by calculation (2 vols.) = 3·08.

Carbamate of Methyl. *Urethylane.* $C^2H^5NO^2 = CH^2(CH^3)NO^2$.—Obtained like the preceding compounds. Crystallises in long tables derived from an oblique rhomboïdal prism, with very elongated terminal faces. The crystals are not deliquescent, they melt between 52° and 55° C., and solidify at 52° when perfectly dry. Boiling-point 177° C. Vapour-density, experimental = 2·62; by calculation (2 vol.) = 2·60. It is very soluble in water, less in alcohol, and still less in ether. 100 pts. of water at 11° C. dissolve 217 pts. of it, whereas 100 pts. alcohol at 15° C. dissolve only 73 pts. Dilute sulphuric acid decomposes urethylane into methylic alcohol, acid sulphate of ammonium, and carbonic anhydride:

$$\left.\begin{matrix}NH^2(CO)''\\CH^3\end{matrix}\right\}O + \left.\begin{matrix}SO^2\\H^2\end{matrix}\right\}O^2 + H^2O = CH^3.H.O + \left.\begin{matrix}SO^2\\H.NH^4\end{matrix}\right\}O^2 + CO^2.$$

Strong sulphuric acid blackens it, eliminating sulphurous anhydride and inflammable gases. Potash decomposes it in the same manner as dilute sulphuric acid.

Carbamate of Tetryl. $C^5H^{11}NO^2 = CH^2(C^4H^9)NO^2$.—Obtained by heating tetrylic alcoholic with liquid chloride of cyanogen, best in a sealed tube, distilling and collecting that which passes over above 220° C. This distillate solidifies on cooling in a crystalline mass, which, when recrystallised from boiling alcohol, forms shining nacreous scales, unctuous to the touch, insoluble in water, soluble in alcohol and ether; they melt at a gentle heat and distil without alteration. (Humann, Ann. Ch. Phys. [3] xliv. 340.)

Substitution-derivatives of Carbamic Acid.

Ethyl-carbamic Acid. $C^3H^7NO^2 = \left.\begin{matrix}NH(C^2H^5)(CO)''\\H\end{matrix}\right\}O$.—This acid, isomeric with urethane, is not known in the free state; but its ethylammonium-salt, $\left.\begin{matrix}NH(C^2H^5)(CO)''\\C^2H^8N\end{matrix}\right\}O$, is identical with the so-called *anhydrous carbonate of ethylamine*, $(C^2H^7N)^2.CO^2$, obtained by passing carbonic anhydride into anhydrous ethylamine cooled by a freezing mixture. It is a snow-white powder, whose aqueous solution, like that of carbamate of ammonium, does not immediately precipitate chloride of barium, unless aided by heat. (Wurtz, Ann. Ch. Phys. [3] xxx. 483.)

Ethylcarbamate of Ethyl. *Ethylurethane.* $C^5H^{11}NO^2 = C^3H^6(C^2H^5)NO^2$.—Produced by heating cyanate of ethyl with alcohol in a sealed tube: $C(C^2H^5)NO + C^2H^6O = C^5H^{11}NO^2$; sometimes obtained as an accessory product in the preparation of cyanate of ethyl. It is an oily liquid, smelling like carbonate of ethyl. Specific gravity 0·9862. Boiling point 174—175° C. Vapour-density 4·071. Potash decomposes it, forming alcohol, ethylamine, and carbonate of potassium: $C^5H^{11}NO^2 + 2KHO = C^2H^6O + C^2H^7N + K^2CO^3$. Heated with strong sulphuric acid, it yields carbonic anhydride, sulphate of ethylamine, and probably also ethylsulphuric acid. (Wurtz, Compt. rend. xxxvii. 182; Gerh. ii. 929; iv. 869.)

Methyl-carbamic Acid, like the corresponding ethyl-compound, is not known in the separate state, but forms a methylammonium-salt, $\left.\begin{matrix}NH(CH^3)(CO)''\\CH^6N\end{matrix}\right\}O$, which may also be regarded as *anhydrous carbonate of methylamine*, $(CH^5N)^2.CO^2$: it is formed by passing carbonic anhydride into dry methylamine, or by distilling a mixture of fused hydrochlorate of methylamine and carbonate of calcium. In the latter case, however, it is mixed with carbonate of methylamine. (Wurtz, Ann. Ch. Phys [3] xxx. 450, 461.)

Phenyl-carbamic Acid. *Carbanilic Acid. Anthranilic Acid.* $C^7H^7NO^2 = \left.\begin{matrix}NH(C^6H^5)(CO)''\\H\end{matrix}\right\}O$. (Fritzsche, Ann. Ch. Pharm. xxxix. 83; Liebig, *ibid.* xxxix. 91; Gerland, Chem. Soc. Qu. J. v. 133.)—This acid, which contains the elements of 1 at. carbonic anhydride and 1 at. phenylamine, C^6H^7N, and is likewise isomeric with oxybenzamic acid, is obtained by boiling indigo with strong caustic potash, replacing the water as it evaporates, and adding peroxide of manganese before the indigo completely disappears, till the liquid no longer deposits blue indigo on being left at rest. The mass is then dissolved in water and supersaturated with dilute sulphuric

acid; the filtered liquid is neutralised with potash and evaporated to dryne
residue is digested with alcohol, which dissolves chiefly phenyl-carbamate o
and leaves it in an impure state when evaporated. It is then dissolved in
acid added, and the yellow or brownish crystals of phenyl-carbamic
precipitated are purified by animal charcoal and recrystallisation (
According to Chancel this acid is likewise produced by the action of potas
carbamide.

Phenyl-carbamic acid crystallises in transparent, colourless, shinin
laminæ, often of considerable size. It dissolves very sparingly in cold water
in boiling water, very easily in alcohol and ether. Its solutions have an
It melts at 132° C., and sublimes unaltered. By distillation from coars
glass, it is resolved into carbonic anhydride and phenylamine. It carb
heated with phosphoric anhydride. Strong sulphuric acid converts it into
phamic acid. When nitrous acid gas is passed into its warm dilute aque
nitrogen is evolved, and the solution yields, when concentrated, crystals
(phenyl-carbonic acid):

$$\left.\begin{matrix}NH(C^6H^5)(CO)''\\H\end{matrix}\right\}O + HNO^2 = \left.\begin{matrix}(CO)''\\.H.C^6H^5\end{matrix}\right\}O^2 + H^2O + N^2.$$

Phenyl-carbamic acid. Nitrous acid. Phenyl-carbonic acid.

The metallic phenyl-carbamates are but little known. The *calcium-salt*,
forms rhombohedral crystals, sparingly soluble in cold, moderately in boiling
silver-salt, $C^7H^6AgNO^2$, is deposited in shining laminæ on mixing a di
solution of the calcium-salt with nitrate of silver. The solution of the am
likewise precipitates the salts of *copper*, *lead*, and *zinc*.

Phenyl-carbamates (?) *of Ethyl and Methyl.*—Chancel (Compt. rend. x
treating the nitrobenzoates of ethyl and methyl with sulphydrate of amn
tained compound ethers, which he regards as phenyl-carbamates; but
mode of formation it is more probable that they are oxybenzamates, wh
meric therewith. (See OXYBENZAMIC ACID.)

CARBAMIDE. $CH^4N^2O = N^2.(CO)''.H^2.H^2$.—This compound is
diamide of carbonic acid, and has the same composition as urea, with whi
is in all probability identical. It is formed in various ways:

1. By the action of ammonia on oxychloride of carbon, both being p
(Regnault, Ann. Ch. Phys. [2] lxix. 180; Natanson, Ann. Ch. Pharm.

$$COCl^2 + 4NH^3 = CH^4N^2O + 2NH^4Cl.$$

The mixture of carbamide and sal-ammoniac thus produced is soluble in w
aqueous alcohol; and on adding excess of baryta-water to the solution, ev
vacuo, exhausting the residue with absolute alcohol, evaporating to drynes
in a small quantity of water, treating the solution with nitric acid, and
the resulting nitrate of carbamide with carbonate of barium, the carbamide
in the separate state (Natanson).—2. By the action of ammonia on
ethyl. When the two substances are heated together in a sealed tube
carbamate of ethyl is first formed (at 100°), and afterwards converted b
of ammonia into carbamide:

$$(CO)''(C^2H^5)^2O^2 + NH^3 = C^2H^6.H.O + \left.\begin{matrix}NH^2(CO)''\\C^2H^5\end{matrix}\right\}O.$$

$$\left.\begin{matrix}NH^2(CO)''\\C^2H^5\end{matrix}\right\}O + NH^3 = C^2H^6.H.O + N^2(CO)''.H^4.$$

3. By the action of heat on the isomeric compound, cyanate of ammonium,
or even when a solution of that salt is left to evaporate spontaneously,
cyanate of potassium is mixed with sulphate of ammonium, the mixture le
rate, and the residue exhausted with alcohol.—4. By decomposing amn
fulminate with sulphydric acid (see FULMINIC ACID).—5. In the decompos
amide (*q. v.*) at a red heat.—6. By the oxidation of uric acid.

The product obtained by the last four processes is urea; the same subst
as an animal excretion in the urine, in which indeed it was first discov
produced by the oxidation of the nitrogenous tissues. Whether the carb
duced by the action of ammonia on carbonic ether or on oxychloride o
identical with this, or only isomeric, is a point perhaps not absolutely decide
theless it agrees with urea in its most essential characters, viz. in forming
soluble crystalline salt with nitric acid, and in being resolved by the ac
stronger acids into ammonia and carbonic anhydride, as represented by the

$$CH^4N^2O + H^2O = 2NH^3 + CO^2.$$

nault did not obtain a crystalline salt by adding nitric acid to the de and sal-ammoniac produced by the first process; perhaps in consence of the sal-ammoniac. Natanson, however, did obtain a cryse manner above described. No decided difference has, indeed, been en carbamide and urea. We shall, however, refer to the article ration and properties of the substance usually so called, and shall nber of substitution-products, commonly called *compound ureas.*

itution-products of Carbamide: Compound Ureas.

carbamide may be more or less replaced by organic radicles, acid or nds containing 1 at. of an alcohol-radicle, are obtained chiefly by the on the cyanates of those radicles, just as carbamide or urea itself is tion of ammonia on cyanic acid (cyanate of hydrogen.)

$$\underset{\text{Cyanic Acid.}}{HCNO} + NH^3 = \underset{\text{Carbamide.}}{CH^4N^2O.}$$

$$\underset{\text{Cyanate of Ethyl.}}{C^2H^5.CNO} + NH^3 = \underset{\text{Ethyl-carbamide.}}{CH^3(C^2H^5)N^2O.}$$

tain 2 at. of an alcohol-radicle are produced in like manner by the -base on the cyanate of an alcohol-radicle, *e.g.* ethyl-allylcarbamide, ylamine on cyanate of allyl. All these carbamides containing basic line-salts with nitric acid, and are resolved by the action of sulphuric l, or of alkalis, into carbonic anhydride and an amine base, just as ed under similar circumstances into carbonic anhydride and ammonia. containing acid radicles are produced by the action of the chlorides urea. They do not form salts with nitric acid. When heated they anuric acid and the corresponding acid amide (*vide infra*).

s or *Ureas containing Acid radicles.* (Zinin, Ann. Ch. Pharm. nhauer, *ibid.* xciv. 100.)

MIDE. $C^3H^6N^2O^2 = N^2\left\{\begin{matrix}(CO)''\\ C^2H^3O.\\ H^3\end{matrix}\right.$ Crystallises from boiling alcohol es, and from boiling water, in stars or tufts of rhomboïdal prisms s. of cold and 10 pts. of boiling alcohol; much more soluble in ether. At 160° C. it yields a slight woolly sublimate; melts at 12° (Moldenhauer), and at a higher temperature is resolved into cetamide:

$$3C^3H^6N^2O^2 = C^3H^3N^3O^3 + 3(N.H^2.C^2H^3O).$$

ed by nitric acid or by mercuric nitrate.

AMIDE. $C^8H^8N^2O^2 = N^2.(CO)''.C^7H^5O.H^3$.—Obtained by heating chloride of benzoyl to 150°—155° C. As soon as all the urea is hloride, the mixture must be removed from the bath and briskly it becomes pasty. The product washed with cold alcohol yields as a crystalline powder. It crystallises from boiling alcohol in ngular laminæ, often united in groups. It is much less soluble in than in cold alcohol; strong boiling hydrochloric acid dissolves it vater. Heated on platinum-foil it melts, emitting the odour of benzonitrile), afterwards that of cyanic acid, and finally volatilises d to 200° C. in a tube, it melts to a colourless liquid, which at a , is resolved into cyanuric acid and benzamide. Ammonia has no carbamide. Potash dissolves it readily, and acids separate it from alkaline solution, when boiled, gives off ammonia, and forms carbof the alkali-metal.

AMIDE, $C^5H^{10}N^2O^2 = N^2.(CO)''.C^4H^7O.H^3$.—Crystallises readily from s, from alcohol in thin elongated rhombic laminæ. It is tasteless elts at 176° C. to a yellowish liquid which solidifies in a crystalline A high temperature decomposes it like acetyl-urea. Its aqueous pitated by nitric acid, oxalic acid, or mercuric nitrate.

BAMIDE, $C^6H^{12}N^2O^2 = N^2(CO)''.C^5H^9O.H^3$, crystallises from boiling eous crystals, unctuous to the touch; from alcohol in needles. It is cold water, melts at 91° C. and when carefully heated yields a subescent scales.

β. *Carbamides* or *Ureas containing Basylous radicles:*

Allyl-carbamide, $C^4H^8N^2O = N^2.(CO)''.C^3H^5.H^3$. (**Cahours and Hofmann**, Phil. Trans. 1855, p. 555.)—Obtained by the action of ammonia on cyanate of allyl ($C^3H^5.CNO + NH^3 = C^4H^8N^2O$.) Crystallises easily by evaporation both from wate and from alcohol. Its composition is that of thiosinamine in which the sulphur is replaced by oxygen.

Allyl-sulphocarbamide, $N^2.(CS)''.C^3H^5.H^3$, also called **thiosinamine**, is produce by the action of ammonia on oil of mustard. Ethyl-, phenyl-, and naphthyl-derivative of it are produced by treating oil of mustard with ethylamine, phenylamine and naphthylamine.

Diallyl-carbamide. *Sinapoline.* $C^7H^{12}N^2O = N^2.(CO)''.(C^3H^5)^2.H^2$. — Produced 1. By the action of oxide of lead and water on sulphocyanate of allyl (oil of mustard)

$$2(C^3H^5.CNS) + 3Pb^2O + H^2O = C^7H^{12}N^2O + Pb^2CO^3 + 2Pb^2S.$$

2. By heating cyanate of allyl with water or with aqueous potash:

$$2(C^3H^5.CNO) + H^2O = C^7H^{12}N^2O + CO^2.$$

If potash is used, care must be taken that the action does not go too far; otherwis nothing but amine-bases will be formed (**Cahours and Hofmann.** *loc. cit.*) For th properties and reactions of this compound, see Sinapoline.

Amyl-carbamide. $C^6H^{14}N^2O = N^2.(CO)''.C^5H^{11}.H^3$. (A. **Wurtz**, Compt. rend xxxii. 417).—Produced by the action of ammonia on cyanate of amyl. It is decompose by potash into amylamine and carbonate of potassium. It forms a crystalline nitrate

Benzyl-carbamide. *Toluyl-urea.* $C^8H^{10}N^2O = N^2.(CO)''.C^7H^7.H^3$.—This sub stance, or more probably an isomer thereof, is produced by the action of sulphydrate o ammonium on nitrotoluamide. (**Noad**, Phil. Mag. [4] vii. 142. (See Toluamide.)

Ethyl-carbamide, $C^3H^8N^2O = N^2.(CO)''.C^2H^5.H^3$. (**Wurtz**, Compt. rend. xxxii 414.)—Produced by the action of ammonia on cyanate of ethyl. Dissolves readily i water and alcohol, and crystallises from alcohol in large prisms which decompose a 200° C., with evolution of ammonia and other products. The aqueous solution is decomposed by chlorine, forming a heavy liquid which crystallises gradually. Nitric aci does not form a precipitate in the aqueous solution, but crystals of nitrate of ethyl carbamide are obtained on evaporation.

Diethyl-carbamide, $C^5H^{12}N^2O = N^2.(CO)''.(C^2H^5)^2.H^2$.—Produced, like the allyl compound, by the action of water on cyanate of ethyl; also by the action of ethylamin on cyanate of ethyl: $C^2H^5.CNO + C^2H^7N = C^5H^{12}N^2O$. The nitrate forms very aci deliquescent rhombic prisms containing $C^5H^{12}N^2O.HNO^3$. (**Wurtz.**)

Ethyl-allyl-carbamide, $C^6H^{12}N^2O = N^2.(CO)''.C^2H^5.C^3H^5.H^2$. (**Cahours an Hofmann**, *loc. cit.*)—By the action of ethylamine on cyanide of allyl. Crystallises i beautiful prisms.

Similar compounds are formed by the action of methylamine, amylamine, an phenylamine on cyanate of allyl.

Ethyl-allyl-sulphocarbamide, $N^2(CS)''.C^2H^5.C^3H^5.H^3$. Syn. of Ethylthiosinamine. (See Thiosinamine.)

Ethyl-amyl-carbamide, $C^8H^{18}N^2O = N^2(CO)''.C^2H^5.C^5H^{11}.H^2$. — Action of amylamine on cyanate of ethyl. (**Wurtz.**)

Methyl-carbamide, $C^2H^6N^2O = N^2.(CO)''.CH^3.H^3$. (**Wurtz**, *loc. cit.*)—Obtained by the action of ammonia on cyanate of methyl; also by evaporating a mixtur of sulphate of methylamine and cyanate of potassium and extracting the residue wit alcohol. Crystallises in long transparent deliquescent prisms. The aqueous solutio is neutral to test-paper, and if somewhat concentrated yields with nitric acid a precipitate of $C^2H^6N^2O.HNO^3$.

Dimethyl-carbamide, $C^3H^8N^2O = N^2.(CO)''.(CH^3)^2.H^2$. (**Wurtz.** *loc. cit.*)—Isomeri with ethyl-carbamide. Produced by the action of water, or of methylamine on cyanat of methyl. Crystallises easily; melts at 97° C.; is permanent in the air; volatilises without alteration; dissolves readily in water and alcohol; combines wit nitric acid, forming the salt $C^3H^8N^2O.HNO^3$.

Methyl-ethyl-carbamide $C^4H^{10}N^2O = N^2.(CO)''.CH^3.C^2H^5.H^2$.—Very deliquescen substance, obtained by the action of methylamine on cyanate of ethyl. (**Wurtz.**)

Naphthyl-carbamide, $C^{11}H^{10}N^2O = N^2(CO'').C^{10}H^7.H^3$. (**H. Schiff**, Chem Ga 1857, p. 211.)—Obtained by saturating a solution of naphthylamine in anhydrou ether with cyanic acid gas, and recrystallising from hot alcohol. Flat, shining, flexibl needles, nearly insoluble in water, more soluble in alcohol, easily soluble in ether: th latter solution yields a crystalline precipitate with oxalic acid. Naphthyl-carbamid yields by spontaneous decomposition, a resinous substance, whose alcoholic solution

acids, and red again by alkalis. The same reaction has been ob-
uced on test-paper by a tincture of madder (Sacc), and by nitroso-
ch and Perkin, Jahresber. f. Chem. 1856, p. 609).

L-SULPHOCARBAMIDE. $N^2(CS'').C^{10}H^7.C^3H^5.H^2$.—Syn. of NAPHTHYL-
See THIOSINAMINE.)

AMIDE, $C^7H^8N^2O = N^2.(CO)''.C^6H^5.H^3$. *Phenyl-urea, Aniline-urea,*
rbamide-carbanilide. (A. W. Hofmann, Ann. Ch. Pharm. liii. 57;
0; lxxiv. 14; Gm. xi. 503.)—This compound is obtained: 1. By
d vapour into anhydrous phenylamine, kept as cool as possible; dis-
ing crystalline mass in hot water; filtering to separate diphenyl-
is produced more abundantly in proportion as the phenylamine has
d); and cooling the filtrate to the crystallising point.—2. By
or hydrochlorate of phenylamine with aqueous cyanate of potassium,
e resulting phenyl-carbamide (cyanate of phenylamine) by diges-
3. By mixing phenylamine with an aqueous solution of chloride of
d by passing chlorine gas through aqueous hydrocyanic acid), puri-
g crystals with animal charcoal, and recrystallising from hot water.
henyl mixed with ammonia, immediately solidifies in the form of
$C^6H^5.CNO + NH^3 = C^7H^8N^2O$.

de forms fusible needles and laminæ, sparingly soluble in cold, easily
sily also in *alcohol* and *ether*. It dissolves in *nitric acid*, but scarcely
nt than in water, and crystallises therefrom unaltered, differing in
carbamide. It dissolves also without alteration in *cold sulphuric*
ated therewith, it is resolved into carbonic anhydride,, phenyl-sulph-
d sulphate of ammonium:

$$+ 2H^2SO^4 = CO^2 + \left.\begin{matrix}N.H.C^6H^3.(SO^2)''\\ H\end{matrix}\right\}O + NH^4.H.SO^4.$$

melting-point, it is resolved into ammonia, diphenyl-carbamide, and

$$\underset{\text{amide.}}{C^6H^5.H^3]} = 3NH^3 + \underset{\text{Diphenyl-carbamide.}}{3[N^2.(CO)''.(C^6H^5)^2.H^2]} + \underset{\text{Cyanuric acid.}}{N^3.H^3.(\overset{\prime\prime}{C}O)^3}$$

rong *potash-ley*, or more quickly by fusion with *hydrate of potassium*,
phenylamine, and carbonate of potassium:

$$^7H^8N^2O + 2KHO = NH^3 + C^6H^7N + K^2CO^3.$$

ed by boiling with dilute acids or alkalis.
l-urea has hitherto been generally applied to the isomeric compound,
ained by the action of sulphydrate of ammonium on nitrobenzamide
427). This compound is a powerful base; but it does not agree with
n its mode of formation, or in its reaction with alkalis. It should
l as *oxybenzodiamide* (*q. v.*) the primary diamide of oxybenzoic acid
mation may be represented by the equation:

$$\underset{\text{benzamide.}}{\begin{matrix}H^4(NO^2)O\\ H^2\end{matrix}} + 3H^2S = \underset{\text{Oxybenzo-diamide.}}{N^2\left\{\begin{matrix}(C^7H^4O)''\\ H^4\end{matrix}\right.} + 2H^2O + S^3.$$

n potash, it yields ammonia, and an acid which is probably oxyben-
action consists of two stages, ammonia and oxybenzamic acid being
, ammonia and oxybenzoic acid in the second:

$$\underset{\text{Oxybenzo-diamide.}}{\left\{\begin{matrix}(C^7H^4O)''\\ H^4\end{matrix}\right.} + H^2O = NH^3 + \underset{\text{Oxybenzamic acid.}}{\left.\begin{matrix}N.H^2.(C^7H^4O)''\\ H\end{matrix}\right\}O}$$

$$\underset{\text{Oxybenzamic acid.}}{\left.\begin{matrix}N.H^2.(C^7H^4O)''\\ H\end{matrix}\right\}O} + H^2O = NH^3 + \underset{\text{Oxybenzoic acid.*}}{\left.\begin{matrix}C^7H^4O\\ H^2\end{matrix}\right\}O^2}$$

l-urea is the compound above described as phenyl-carbamide.

CARBAMIDE, $C^9H^{12}N^2O = N^2.(CO)''.C^2H^5.C^6H^5.H^2$, is obtained by dis-
ine in cyanate of ethyl. Great heat is evolved, and the mixture
es to a crystalline mass. It is slowly decomposed by potash, yield-
ethylamine, and carbonic anhydride. (Wurtz, Compt. rend. xxxii.

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r. Hofmann (Proc. Roy. Soc. x. 602), where however the acid formed is said to
t benzoic acid.

Nitrophenyl-carbamide, $C^7H^7N^3O^3 = N^2.(CO)''.C^6H^4(NO^2).H^3$. — Produ
ther with dinitromelaniline, by the action of gaseous chloride of cyanogen
phenylamine dissolved in ether. (Hofmann, Ann. Ch. Pharm. lxvii. 156 ;

Diphenyl-carbamide. *Diphenyl-urea, Carbanilide, Carbophenylamide.* C^{13}
$N^2.(CO)''.(C^6H^5)^2.H^2$ (Hofmann, Ann. Ch. Pharm. lvii. 266; Gm. xi. 3
duced: 1. By the action of cyanate of phenyl on phenylamine, or on water

$$2[N.(CO)''.C^6H^5] + H^2O = CO^2 + N^2.(CO)''.(C^6H^5)^2.H^2.$$

2. By the action of phenylamine on oxychloride of carbon.—3. In the dec
of diphenyl-sulphocarbamide by potash.—4. By the dry distillation of
bamide, melanoximide, or oxalate of melaniline. (See those compounds.)

Diphenyl-carbamide forms white silky needles, which melt at 205° C.
without decomposition. It is odourless at ordinary temperatures, but has a
odour when heated. It dissolves sparingly in *water*, abundantly in *alcohol*

When quickly heated in the moist state, it yields carbonate of phenylamin
with other products. With strong *sulphuric acid*, it gives off carbonic anhy
forms water and phenylsulphamic acid:

$$N^2\left\{\begin{matrix}(CO)'' \\ (C^6H^5)^2 \\ H^2\end{matrix}\right. + 2\left(\begin{matrix}SO^2 \\ H^2\end{matrix}\right\}O^2\Big) = (CO)''.O + H^2O + 2\Big(\begin{matrix}N.H.C^6H^5.(SO^2)'' \\ H\end{matrix}$$

By boiling with *potash*, it is resolved into phenylamine and carbonate of p

Diphenyl-carbamide is isomeric with *flavine*, an organic base produced by
of reducing agents on dinitrobenzophenone. This base is indeed sometime
as diphenyl-urea (Gerh. i. 430); but it does not exhibit the characters
(See Flavine.)

Phenylsulphocarbamide, $C^7H^8N^2S = N^2(CS)''.C^6H^5.H^3$. (Hofman
ings of the Royal Society, ix. 276.)—Produced by the action of alcoholic amm
phocyanate of phenyl:

$$C^6H^5.CNS + NH^3 = C^7H^8N^2S.$$

The mixture, on being gently warmed, quickly solidifies into a crystalline
which may be obtained in beautiful needles by crystallisation from boiling

Phenylsulphocarbamide is a weak base, and forms a *chloroplatinate*
$C^7H^8N^2S.HCl.PtCl^2$. It also combines with *nitrate of silver*. By boiling
of silver, it is converted into phenyl-carbamide.

Phenyl-allyl-sulphocarbamide. $N^2.(CS)''.C^6H^5.C^3H^5.H^2$. — Syn. with
Thiosinamine. (See Thiosinamine.)

Diphenyl-sulphocarbamide. *Sulphocarbanilide, Sulphophenyl-urea.* C
$N^2(CS)''.(C^6H^5)^2.H^2$. (Hofmann, Ann. Ch. Pharm. lvii. 266; lxx. 144; G
Further, Proc. Roy. Soc. x. 274.—Laurent and Delbos, J. Pharm. [3
Laurent and Gerhardt, Ann. Ch. Phys. [3] xxii. 103; xxiv. 196.)—Thi
is obtained: 1. By the action of sulphide of carbon on phenylamine, the a
accelerated by addition of alcohol (Hofmann):

$$2C^6H^7N + CS^2 = C^{13}H^{12}N^2S + H^2S.$$

—2. By heating a mixture of phenylamine, sulphocyanate of potassium, an
acid, the diphenyl-sulphocarbamide then distilling over, while sulphate of
remains behind (Laurent and Gerhardt).—3. By mixing phenylamine
cyanate of phenyl: $C^6H^5.CNS + C^6H^7N = C^{13}H^{12}N^2S$. (Hofmann.)

Diphenyl-sulphocarbamide separates from the mixture of phenylamine a
of carbon, in crystalline scales or rhombic tables; from alcohol, in brillian
laminæ. It dissolves sparingly in water, easily in alcohol. It has a pecu
especially when heated, and a bitter taste exceeding in intensity that o
known substance. It melts at 140° C., and distils without decompositio
with strong *sulphuric acid*, it forms phenyl-sulphamic acid, giving off carboni
and sulphydric acid (Hofmann):

$$C^{13}H^{12}N^2S + 2H^2SO^4 = CO^2 + H^2S + 2\left(\begin{matrix}N.H.C^6H^5.(SO^2)'' \\ H\end{matrix}\right\}O$$

By *phosphoric anhydride, chloride of zinc*, or *hydrochloric acid gas*, it
into phenylamine and sulphocyanate of phenyl (Hofmann). Fused with
yields phenylamine, together with sulphydrate and carbonate of potassium

$$C^{13}H^{12}N^2S + 3KHO = 2C^6H^7N + K^2CO^3 + KHS.$$

When boiled with *alcoholic potash*, it is converted into diphenyl-carbamide

$$C^{13}H^{12}N^2S + K^2O = K^2S + C^{13}H^{12}N^2O.$$

its alcoholic solution is boiled with *mercuric oxide.* It is not decom-
acids or alkalis.

RBAMIDE. *Piperyl-urea, Piperidine-urea.* $C^6H^{12}N^2O = N^2(CO)''.C^6H^9.H^3$
. Ch. Phys. [3] xxxviii. 76.)—Obtained by boiling sulphate of pipe-
nate of potassium, evaporating to dryness, and exhausting with strong
ears also to be formed when vapour of cyanic acid or moist chloride of
sed into piperidine. The alcoholic solution yields it, by spontaneous
ong white needles.

l-carbamide, $C^6H^{11}(CH^3)N^2O$, and *Ethyl-piperyl-carbamide*,
, are produced by the action of piperidine on the cyanates of methyl

L. Syn. of Cyanate of Phenyl. (See Cyanic Ethers.)

LIDE. Syn. of Diphenyl-carbamide (p. 756).

LIC ACID. Syn. of Phenyl-carbamic Acid (p. 751).

LETHANE and **CARBANIMETHYLANE.** Phenylcar-
nyl and Methyl (p. 752).

TE. The name given by Thaulow (J. pr. Chem. xxxi. 220) to the
ignition of cyanide of silver, which he regards as isomeric but not
yanogen. It has a peculiar odour, and strongly irritates the eyes and
ns. Specific gravity 1·73. Liquefies at −4° C. Burns with red
lves in potash, and the solution when neutralised with nitric acid does
ron-salts. (Thaulow.)

TIC ACID. Syn. with Picric Acid.

S, or *Carburets.* Compounds of carbon with metals. These com-
; been much studied: none of them occur as natural minerals, and it
tain them in definite form. The usual effect of the union of carbon
to render it hard and brittle. (See the several metals.)

NZIDE. Syn. with Benzone.

NZOIC ACID. See Cinnamein (p. 981).

YDROGENS. See Hydrocarbons.

C ACID. Syn. with Phenic Acid.

Symbol C. *Atomic weight* 12.—Carbon is one of the most abundant
, existing both in the free state and in an endless variety of combina-
und pure in the diamond; nearly pure in graphite or plumbago, less
cite. It occurs also abundantly in the form of carbonates, especially
cium, and is an essential constituent of organic bodies, from which
ated in the form of charcoal, by distilling off the more volatile elements,
en, nitrogen, &c.

free state is a solid body, destitute of taste and odour, infusible and
epting at the temperature produced by a powerful electric current. The
tions exhibit great diversities of colour, lustre, transparency, hardness,
wer of conducting heat and electricity. It exhibits crystalline forms
different systems, the regular and the hexagonal, and several amor-
ions.

l. This valuable gem consists of pure or nearly pure carbon. It is
l soils produced by the disintegration of ancient rocks, the principal
in India, Borneo, Brazil, and the Urals. Diamonds occur thinly
gh large quantities of soil, and very careful washing and examination
separate them.

crystallises in forms belonging to the regular system, namely, the oc-
is usually the predominating form, though it rarely occurs alone; also
omboïdal dodecahedron, which is very frequent; the triakis-octahedron,
faces, formed by the superposition of a low triangular pyramid on
octahedron; and the hexakis-octahedron, a 48-sided figure formed
by a 6-faced acumination of the octahedron. Intermediate forms are
occurrence, the secondary faces being sometimes so numerous as to
the appearance of having convex faces. Sometimes the faces are really
sequently intersect in curved edges: the dodecahedron and octahedron
with convex faces. Hemihedral forms and twin-crystals are also found.
the article Crystallography.)

cleave easily in directions parallel to other faces of the regular octa-
is therefore the primary form. The fracture is conchoïdal. The

specific gravity of the diamond is 3·5295 according to Thomson; 3·55 acco
Pelouze. It is the hardest substance known, being capable of scratching al
Diamonds with curved edges are also capable of cutting glass, and are mu
for that purpose, the curved edges penetrating the glass like a wedge; those with
edges merely scratch.

The purest diamonds are colourless and transparent; but many exhibit variou
of yellow, red, green, brown, and black; these coloured diamonds leave, whe
from 0·65 to 0·2 per cent. of ash: colourless diamonds leave but a trace. The
has a strong lustre (called *adamantine*), and high refractive and dispersive
hence its peculiar brilliancy. The lustre of the natural diamond is greatly i
by cutting it in a peculiar manner, so as to give it numerous facets capable of r
and dispersing light in various directions. This is effected by pressing the
against a revolving metal disc covered with a mixture of diamond dust an
other substance being hard enough to abrade the diamond. The dust for this
is obtained either by collecting that which falls away in the process of cut
polishing, or by pounding up diamonds which have not sufficient transparen
valuable as gems. Diamonds are sometimes found in opaque spheroïdal lump
tute of crystalline structure and transparency, and useless excepting in the
powder.

The diamond conducts electricity but slowly. Like all other forms of c
neither melts nor volatilises at the heat of the most powerful furnace; but whe
between the charcoal cones of a powerful voltaic battery, it becomes white-ho
up, splits into fragments, and after cooling, presents the aspect of coke prepa
bituminous coal. When very strongly heated in the air or in oxygen gas, it
and burns completely away, forming carbonic anhydride. This fact of the c
bility of the diamond, which had been conjectured by Newton from its great r
power, was first demonstrated in 1694, by the Florentine academicians, who s
in burning it in the focus of a concave mirror. Lavoisier and Guyton-Morv
afterwards Davy, showed that the sole product of the combustion in oxygen is
anhydride, and therefore that the diamond is pure carbon.

2. *Graphite.*—This name is applied to several varieties of native carbon co
from 95 to nearly 100 per cent. of that element, some crystalline, others am
but all perfectly opaque, having an iron-black or steel-grey colour, and metall
producing a black shining streak on paper; sectile; of specific gravity 1·209,
between 1 and 2, and conducting electricity nearly as well as the metals.
was formerly regarded as a carbide of iron, but the iron is now known to be
a state of mixture, as also small quantities of silica and alumina.

α. *Crystallised or Foliated Graphite.*—This variety is found occasionally
six-sided tables belonging to the hexagonal system, cleaving perfectly in the
of the base, and having the basal planes striated parallel to the alternate side
commonly, however, it occurs in foliated or granular masses. It is found imb
quartz near Travancore in Ceylon, and near Moreton Bay in Australia; wit
and sphene at Ticonderoga in the State of New York, and in gneiss at Sto
Massachussets, where it presents a structure between scaly and fine granula
occasional approximation to distinct crystallisations (Dana, ii. 27). It is also
artificially by melting cast-iron containing a large proportion of carbon and
to cool slowly. It is tough and difficult to pulverise by mechanical means, b
be reduced to the state of very thin laminæ by prolonged trituration with wa

β. *Amorphous Graphite.*—This variety, also called *plumbago* or *black lead*,
in Borrowdale, Cumberland, where it occurs in nests of trap in the clay-slat
largely imported into this country from Germany, principally from Griesb
Passau. The Borrowdale mine was formerly very rich, but now appears to
exhausted (see *Ure's Dictionary of Arts, Manufactures and Mines*, iii. 467)
phous graphite is softer than the crystalline variety, and makes a much black
on paper: it is therefore better adapted for the making of pencils. Some
amorphous graphite, occurring in the coal measures, have very much the a
of anthracite: such is the case with the graphite of New Brunswick.

Graphite resembles the other modifications of carbon in being unaltera
heated in close vessels, excepting at the temperature of the electric current, and
ing carbonic anhydride when burnt in contact with oxygen. But it differs e
from all other forms of carbon when subjected to the action of certain oxidisi
such as a mixture of chlorate or acid chromate of potassium with sulphuric
acid, or a mixture of nitric and sulphuric acids. In this case **Brodie** has sho
Ch. Phys. [3] xlvi. 351; further, Phil. Trans. 1860, i.; Ann. Ch. Pharm. cxi
it is converted into a peculiar acid, called *graphitic acid*, which is best ob
heating pulverised graphite with chlorate of potassium and nitric acid, as
yellow vapours are given off, then washing it with a large quantity of water.

h, and repeating this series of operations several times. In this manner
ltimately converted into thin transparent crystals of graphitic acid,
e, however, regards this acid as analogous in composition to the acid
Vöhler obtained by the action of oxidising agents on graphitoïdal silicon;
he supposes that the atomic weight of graphite is different from that
ns of carbon, and equal to 33, which he denotes by the symbol Gr
tituting this value in the preceding formula of graphitic acid, it be-
(See Atomic Weight of Carbon, p. 757; also Graphitic Acid.)
ot be converted into graphitic acid by a single treatment with oxidis-
ver long continued; but by subjecting it to this treatment for a cer-
vashing it with water and igniting, it may be purified and obtained in
minute division. A good way of proceeding is to mix coarsely
e with $\frac{1}{14}$ of its weight of chlorate of potassium, add the mixture to a
ng sulphuric acid equal to twice the weight of the graphite, heat the
er-bath as long as yellow vapours of chloric oxide are evolved, wash
with water, then dry and ignite it; it then swells up and leaves finely
. If the graphite to be purified contains siliceous matters, a little
n should be added to the mixture before heating.
sed for making pencils, for polishing stoves, and other articles, for
friction of machinery, for making crucibles, and in the electrotype
ng the surfaces of wood and other non-conducting materials, so as to
luctive.
te or *stone-coal* is an amorphous variety of carbon containing about 90
element associated with hydrogen, oxygen, nitrogen, and ash. It is
composition and properties between graphite and bituminous coal,
an graphite, and having a higher lustre than ordinary coal. Specific
7. Hardness = 2 to 2·1. It burns with difficulty, requiring a strong
it in a state of active combustion: hence it is fit only for burning in
furnaces; it does not cake together like bituminous coal. Anthracite
ly in South Wales, in the departments of Mayenne and Isère in
Pennsylvania and Rhode Island.
btained from Organic Substances by Dry Distillation or
mbustion.—When animal or vegetable substances are strongly heated
the more volatile elements, viz. the oxygen, hydrogen, and nitrogen,
carbon, are driven off in the form of gaseous products, some of which
ense in the liquid form, while a considerable portion of the carbon re-
the form of a black mass, called charcoal, of greater or less compactness,
nature of the original substance. If the substance thus treated—wood
ple—contains any inorganic materials, such as potash, soda, lime, &c.,
hind with the charcoal. The purest kind of charcoal is that obtained
, starch, or some other organic substance, free from inorganic elements,
l. There then remains a black, brilliant, porous charcoal, which is
on, but contains a small quantity of hydrogen and oxygen, which cannot
en by the most intense and long-continued heat.
coal.—Wood consists of carbon, hydrogen, and oxygen, the two latter
portion to form water. When heated in the open air, it burns com-
th the exception of a small quantity of white ash; but if the supply
only the more volatile ingredients burn away, and the greater part of
ins behind. This is the principle of the process of *charcoal-burning*
d in countries where wood is abundant, on the Harz mountains in
stance. A number of billets of wood are built up vertically in two or
a large conical heap, which is covered over with turf or moistened
les being left at the bottom for the air to get in. A hollow space is
niddle of the heap, to serve as a flue for the gaseous matters which
he heap is set on fire by throwing burning pieces of wood into the
near the top of which, however, a kind of grate, made of billets of
to prevent the burning fuel from falling at once to the bottom. The
proceeds gradually from the top to the bottom, and from the centre
the heap; and as the central portions burn away, fresh wood is con-
in at the top, so as to keep the heap quite full. The appearance of
how the combustion is proceeding; when it is going on properly, the
nd white; if it becomes thin, and especially if a blue flame appears,
the wood is burning away too fast, and the combustion must then be
ally stopping up the holes at the bottom, or by heaping fresh ashes on
s, and pressing them down well so as to diminish the draught. As
bustion is completed, the heap is completely covered with turf or ashes,
for two or three days. It is then taken to pieces, and the portions

still hot are cooled by throwing water or sand upon them. The quantity of
thus obtained varies with the manner in which the combustion is conducted.
of wood yield on the average from 61 to 65 parts by measure, or 24 parts b
of charcoal. When the burning is very carefully conducted, the quantity ma
to 70 per cent. by measure.

In England a large quantity of charcoal is obtained in the dry distillation
for the preparation of acetic acid. For this purpose the wood is heated to r
cast-iron cylinders, whereupon a number of volatile products are given off, in
large quantity of tarry matter, an inflammable spirit called wood-spirit or wood-
and acetic acid; and in the retorts there remains a quantity of charcoal.

For the manufacture of gunpowder, charcoal is sometimes prepared by s
wood in iron cylinders to the action of over-heated steam. (Violette,
Phys. [3] xxiii. 475.)

Wood-charcoal is more or less compact, according to the kind of wood from
is formed. The lighter woods, such as willow, yield a very porous charcoa
comparatively little power of conducting heat and electricity; box-wood
contrary, yields a very compact charcoal, which is a good conductor of
electricity, and is admirably adapted for exhibiting the voltaic light. Th
and conducting power of charcoal are greatly increased by exposing it in clo
to a very high temperature. Charcoal retains the form, and to a considerab
the external structure of the wood, so that a horizontal section exhibits disti
concentric rings and the traces of the medullary rays. When burned it le
1 to 5 per cent. of ash. According to Berthier, 1000 parts of lime-wood leave
of ash; of oak, 25; birch 10; fir 8; hornbeam 26; beech 30.

b. Coke.—Ordinary bituminous coal, which consists of the remains of ancie
and peat-mosses, and appears to have been formed from wood by a process
decay going on without access of air, differs from wood in containing a larger p
of carbon, and less oxygen and hydrogen; it also contains nitrogen derived
tissue of the plants. This substance, when heated in the open air, burns a
wood, leaving nothing but a white ash; but, when strongly heated in cast-ir
ders, it undergoes a decomposition like that which takes place in wood unde
circumstances, a large quantity of volatile products being given off, viz. ca
hydrogen gas (the gas used for illumination) and a tarry liquid containing
and a variety of other products; while a black, dull-looking, porous mass, ca
is left in the retorts. This substance also consists mainly of carbon, mixed,
with a quantity of inorganic constituents, greater than that which occurs in w
coal, so that it leaves a larger amount of ash when burned. The aspect of co
greatly according to the kind of coal from which it is obtained. Bitumin
such as the Newcastle coal, undergo a kind of semi-fusion before they decom
yield a very porous coke, having a brilliant metallic aspect; anthracite, on the
undergoes but little alteration by heating, and yields a coke having very muc
form and aspect of the original mass. Coke is used in the iron districts
Wales and Staffordshire, for reducing the metal from the ore. It is there
from the coal which occurs in the same districts, by partially burning that s
in longitudinal heaps, more or less covered up with the ashes of former fires, t
being to produce a smothered combustion, similar to that already described a
the preparation of wood-charcoal. This process is very wasteful unless caref
ducted.

c. Metallic Carbon, Glance-coal.—This is a very dense form of carbon, c
when certain volatile organic compounds, especially hydrocarbons, are passed
red-hot tubes of porcelain or cast-iron; it collects in the upper part of the r
which carburetted hydrogen gas is distilled from coal, and is likewise pro
blast furnaces. It often exhibits the lustre and sonority of a metal, is very
good conductor of heat and electricity, and burns with difficulty. It is used
the negative element in Bunsen's voltaic battery.

A very hard and compact carbon, also used for the purpose just mentione
tained by heating to redness, in an iron mould, an intimate and impalpable
of 2 pts. coke and 1 pt. bituminous coal, then several times steeping it in tre
subjecting it again to a very intense heat. The mass thus formed is very hard,
sawn and filed without breaking, and conducts electricity like a metal.

d. Lamp-black.—Most of our ordinary combustibles, consisting of carbon
drogen, such as tallow, wax, and oil, undergo but imperfect combustion, unless
by an artificial draught of air. The consequence is, that a portion of the
which is the less combustible element of the two, remains unburned, and is d
in smoke, or deposited on cold surfaces in the form of *soot* or *lamp-black*; thus
of glass or metal held in the upper part of a candle flame is quickly covere
black deposit of carbon. Lamp-black is ordinarily prepared by the imperfect

onised bodies, such as resin or pitch. The apparatus consists of a
amber, in which is suspended a cone of iron plate, having a hole at
moving up and down; this cone serves for a chimney during the
iron pot, containing the resin or pitch, is heated in a furnace out-
the vapours proceeding from it are set on fire; and the supply of
ulated by apertures which may be opened and closed at pleasure.
bustion of the vapour produces a considerable quantity of lamp-
s on the cone and on the walls. When the operation is finished, the
d as it is made to fit the chamber exactly, it scrapes the wall as it
es the deposit to fall down on the floor. Lamp-black thus obtained
ated with oily matter; it may be purified by calcination in a covered
es the chamber is hung with coarse cloths, on which the soot col
hdrawn from time to time and scraped.

of condensation is to cause the smoke and vapour to pass through
e, in which the oily products collect, and thence into a series of con-
the purest product is then found in the farthest chamber. The
-black is obtained by burning oil or fat in lamps, and causing the
stion to pass through a series of iron cylinders, terminating in a
ders are opened at bottom from time to time, and the carbonaceous
As obtained by either of these methods it is always more or less
oily matter. It may be purified by calcination in a covered crucible,
s to which it is chiefly applied, viz. for painting and for the manufac-
, the presence of the oil is not objectionable.

oal or *Bone-black*, is a mixture of very finely divided charcoal and
m obtained by calcining bones in close vessels. Its preparation and
n already described (p. 624).

er of Charcoal.—Wood-charcoal and other porous forms of carbon
f absorbing large quantities of gases: the greater the porosity of the
is also its absorbing power. In its ordinary state, however, charcoal
vith atmospheric air, and to enable it to exert its full absorbing power
must first be freed from the air contained in it by heating it to red-
t under mercury. Saussure has shown that recently ignited box-
orbs at 12° C. and under a pressure of 724 millimetres, the follow-
fferent gases:

. .	90	vols.	Ethylene . .	35	vols.
c acid .	85	„	Carbonic oxide .	9·42	„
anhydride	65	„	Oxygen . . .	9·25	„
acid . .	55	„	Nitrogen . .	6·50	„
le . .	40	„	Hydrogen . .	1·25	„
hydride .	35	„			

sorbs moisture with avidity from the air, as well as other conden-
a as odoriferous effluvia. Hence freshly calcined charcoal, wrapped
n have acquired a disagreeable colour, destroys that odour. It has a
in retarding the putrefaction of animal matter with which it is
Water is found to remain sweet, and wine to be improved in quality,
inside of which has been charred. In the state of coarse powder,
articularly applicable as a filter for spirits, which it deprives of the
contain. (Graham's *Elements of Chemistry*, 2nd ed. vol. i. p. 338.)
ed with offensive gas and other matters may also be rendered fit
ering it through coarsely pounded charcoal interposed between two

ly absorbs gases, but frequently also determines their combination.
oal, which has remained for some time in an atmosphere of sulphu-
nd has absorbed a considerable quantity of that gas, be introduced
d with oxygen, combination immediately takes place between the
ements of the sulphuretted hydrogen, water and sulphurous acid
a portion of the sulphur separated. The charcoal always becomes
times the heat is great enough to produce explosion. Similar phe-
ted by other combustible gases.

charcoal has been applied by Dr. Stenhouse to the construction of
pirators for purifying infected atmospheres. In a pamphlet, bearing
rcoal as a Disinfectant," Dr. Stenhouse observes: — "Charcoal not
ia and gaseous bodies, but, especially, when in contact with atmo-
oxidises and destroys many of the easily alterable ones, by resolving
nplest combinations they are capable of forming, which are chiefly
c acid. . . . Effluvia and miasmata are generally regarded as

highly organised, nitrogenous, easily alterable bodies. When these are ab charcoal, they come in contact with highly condensed oxygen gas, which exi the pores of all charcoal which has been exposed to the air, even for a few in this way they are oxidised and destroyed." On this principle, Dr. Stenl constructed *ventilators*, consisting of a layer of charcoal enclosed between t of wire-gauze, to purify the foul air which accumulates in water-closets, the hospitals, and in the back courts and lanes of large cities. By the use of th lators, pure air may be obtained from exceedingly impure sources, the impuri absorbed and retained by the charcoal, while a current of pure air alone is into the neighbouring apartments. A similar contrivance might also be appl gulley-holes of our common sewers, and to the sinks in private houses. Dr. has also constructed *respirators*, consisting of a layer of charcoal a quarter thick, interposed between two sheets of silvered wire-gauze covered with woo They are made either to cover the mouth and nose, or the mouth alone; kind of respirator affords an effectual protection against malaria and the gases which accumulate in chemical works, common sewers, &c. The answer the same purpose when the atmosphere is not very impure, provided precaution be taken of inspiring the air by the mouth, and expiring by the n form of respirator may also be useful to persons affected with fetid breath. heated wood-charcoal simply placed in a thin layer in trays, and disposed fected apartments, such as the wards of hospitals, is also highly efficacious in the noxious matter.

Platinised Charcoal.—The power of charcoal in inducing chemical comb increased by combination with minutely divided platinum. In this mann bination may be produced possessing the absorbent power of charcoal (whic greater than that of spongy platinum), and nearly equal, as a promoter o combination, to spongy platinum itself. In order to platinise charcoal, not is necessary than to boil it, either in coarse powder or in large pieces, in a dichloride of platinum, and, when thoroughly impregnated, which seldo more than ten minutes or a quarter of an hour, to heat it to redness in a clo a capacious platinum crucible being well adapted for the purpose. Cha platinised, and containing 3 grains of platinum to 50 grains of charcoal, c gen and hydrogen gases to unite completely in a few minutes; with a larger of platinum, the gases combine with explosive violence, just as if platinum- used. Cold platinised charcoal, held in a jet of hydrogen, speedily beco descent, and inflames the gas. Platinised charcoal slightly warmed rapidl incandescent in a current of coal gas, but does not inflame the gas, owing t high temperature required for that purpose. In the vapour of alcohol or w platinised charcoal becomes red-hot, and continues so till the supply of va hausted. Spirit of wine, in contact with platinised charcoal and air, is con few hours into vinegar. Two per cent. of platinum is sufficient to platini for most purposes. Charcoal containing this amount of platinum, causes o hydrogen to combine perfectly in about a quarter of an hour, and such is th of platinised charcoal which seems best adapted for disinfectant respirators. containing only 1 per cent. of platinum causes oxygen and hydrogen to c about two hours; and charcoal containing the extremely small amount of of platinum, produces the same effect in six or eight hours. Platinised char likely to admit of various useful applications; one of the most obvious of adaptability to air-filters and respirators. From its powerful oxidising it might also prove a highly useful application to malignant ulcers and simila which it will act as a mild but effective caustic. It might also be foun Bunsen's carbon battery. (**Stenhouse**, Chem. Soc. Qu. J. viii. 105.)

Charcoal as a Precipitant and Decoloriser.—Wood-charcoal and animal especially the latter, possess the power of forming insoluble compounds dissolved substances, more particularly organic colouring matters. It p iodine from its solution in iodide of potassium, also lime, nitrate of lead, metallic sub-salts, from their aqueous solutions: it likewise separates met from their solutions in alkalis. A solution of acetate or nitrate of lead, in w coal is immersed, is found after a while to contain free acetic or nitric acid. number of organic substances, besides colouring matters, are likewise preci charcoal, viz. the bitter principles of the hop, gentian, and aloes, tannin, org loids; also resins from solution in alcohol. It is important to bear this i analysing liquids which have been decolorised by animal charcoal, as many c stances originally contained in the solution may have been carried down by the

The peculiar power of bone-black in removing colouring matters, &c. from is due to the more minute division of the charcoal resulting from the interp the earthy matter. If this be dissolved out by an acid, the decolorising po

y impaired, which however must be done for certain applications of
paration of vegetable acids. Charcoal of much higher decolorising
black, is obtained by calcining dried blood, horns, hoofs, clippings of
ther animal matters, in contact with pearl-ash, and washing the cal-
vater. A charcoal of considerable decolorising power may likewise
arbonising vegetable substances mixed with chalk, calcined flints, or
matter. If 100 pts. of pipe-clay, made into a thin paste with water,
th 20 pts. of tan and 500 pts. of finely pounded coal, and the mass
in a close vessel, a charcoal will be obtained very little inferior in
r to bone-black. The following table, taken from Graham's *Elements*
d edition, vol. i. p. 361, shows the efficiency of different kinds of
ing colouring matter. These substances are compared with bone-
ne most feeble species. The relative efficiency is not the same for
colouring matter.

cies of Charcoal. (same weight).	Relative decoloration of sulphate of indigo.	Relative decoloration of syrups.
vith pearlash . . .	50	20
vith chalk . . .	18	11
vith phosphate of calcium .	12	10
ith pearlash . . .	36	15·5
harred with the same .	34	15·5
with the same . . .	10·6	8·8
acetate of potassium . .	5·6	4·4
acetate of sodium . .	12	8·8
calcined	4	3·3
cined with pearlash . .	15·2	10·6
after the extraction of the es by an acid, and calcina- ash	45	20
treated with an acid . .	1·87	1·6
h phosphate of calcium .	2	1·9
n its ordinary state . .	1	1

ation, properties, and uses of the various forms of carbon, see further.
of Arts, Manufactures and Mines, articles Bone-Black, Charcoal,
Black.—Pelouze et Frémy, *Traité de Chimie*, 3me éd. i. 705—821.]

of Carbon.—Carbon unites with most other elements, but generally
ctly, most of its compounds being formed either in the bodies of living
s in a way which we cannot trace, or derived by substitution from such
only elements with which it unites directly are oxygen, sulphur, nitro-
etals, and with these only at high temperatures. For *oxygen*, carbon
ty at ordinary temperatures, but at a red heat, it not only combines
oxygen, but is capable of separating that element from its combinations
ven from potassium. The temperature required for determining the
nds upon the density of the carbon: porous wood charcoal begins to
about 240° C.; the more compact kinds require a higher temperature;
aphite still higher; and the diamond the highest of all. The product
n is carbonic anhydride, CO^2, mixed, however, if the supply of oxygen
the lower oxide CO.

carbon also unites at a red heat, forming disulphide of carbon, CS^2.—
unites at a red heat, provided an alkali be present, forming cyanogen,
into combination with the alkali-metal; thus, when nitrogen gas is
ed charcoal saturated with carbonate of potassium, cyanide of potas-
-With *metals* also, carbon appears to unite directly under certain cir-
the formation of steel by keeping iron imbedded in charcoal powder

s of carbon and *hydrogen* constitute a very important group of organic
them, as oil of turpentine, $C^{10}H^{16}$, existing ready formed in plants,
ethylene, C^2H^4, and naphthalene, $C^{10}H^8$, are produced by the decom-
complex organic compounds. Most of them play the part of radicles,
combining, like metals, with chlorine, oxygen, sulphur, &c., of re-
in combination, and passing as entire groups from one state of com-

bination to another: *e.g. ethyl*, C^2H^5, *amyl*, C^5H^{11}, *allyl*, C^3H^5, *ethylene*, C
lene, C^5H^{10}, &c. The hydrogen in these hydrocarbons, may be more or less
by chlorine, bromine, nitryl (NO^2), and other elements or groups, whereby d
radicles are formed, also capable of entering into combination, replacing hydr
like simple radicles, *e. g. bromethyl*, C^2H^4Br, *chlorethylene*, C^2H^3Cl, *dinitronap*
$C^{10}H^6(NO^2)^2$, &c. When the hydrogen in a hydrocarbon is thus completely rep
another element, a chloride, bromide, &c. of carbon is produced. In this
tetrachloride of carbon CCl^4, is formed from marsh-gas CH^4, dichloride o
C^2Cl^4, from ethylene, C^2H^4, &c.

CARBON, BROMIDES OF. Several of these compounds appear to
only one of them, the *dibromide* C^2Br^4, has been analysed.* This body is ob
treating alcohol or ether with bromine, saturating the resulting hydrobr
with potash, distilling, and treating the residue with water. Dibromide
then remains as a white crystalline deposit which may be purified by washing
(Löwig, Ann. Ch. Pharm. iii. 292). Its formation is represented by the eq

$$\underset{\text{Alcohol.}}{C^2H^6O} + 4Br^2 = C^2Br^4 + 4HBr + H^2O.$$

$$\underset{\text{Ether.}}{C^4H^{10}O} + 8Br^2 = 2C^2Br^4 + 8HBr + H^2O.$$

It is also produced by the action of alcoholic potash on the dibromide of trib
lene (Lennox, Chem. Soc. Qu. J. xiv. 209):

$$C^2HBr^3.Br^2 + KHO = C^2Br^4 + KBr + H^2O.$$

Dibromide of carbon forms white crystalline plates, unctuous to the touch,
ethereal odour and saccharine taste; it melts at 50° C., and sublimes without
It is nearly insoluble in water, very soluble in alcohol and ether; not decom
acids or alkalis. It burns in the flame of a spirit lamp, giving off vapours
bromic acid, but ceases to burn as soon as it is removed from the flame.
attacks it in the melted state, forming chloride of bromine. Heated with
mercury or passed over red-hot oxide of zinc, copper, or iron, it yields metalli
and carbonic anhydride. When passed over red-hot metallic zinc, copper,
also yields a bromide of the metal without disengagement of gas. (Lowig.

Commercial bromine sometimes contains a liquid bromide of carbon, which
be obtained by the action of bromine on ether and alcohol, especially if chlori
wise present. It is an oily, colourless, fragrant liquid of specific gravity
solidifiable at − 25° C., boiling at 120° C., so that it is easily separated from b
distillation. It is insoluble in water, not decomposed by acids or dilute al
decomposed by fusion with hydrate of potassium, into bromide and carbonate
sium (Poselger, Ann. Ch. Pharm. lxiv. 287). The same compound appe
produced by the action of 2 pts. bromine on 1 pt. iodide of ethylene, $C^2H^4I^2$,
be separated from bromide of iodine by means of dilute potash.

In the preparation of bromine, there is sometimes formed an oily ether
called *oil of bromine*, which appears to contain $C^2H^3Br^4$. When dropped o
fragments of glass, it yields a deposit of carbon, together with crystals and a d
oil, while hydrobromic acid and a combustible gas escape. The dark-brown o
to be a portion of the liquid which has remained undecomposed and has
bromine, and the crystals consist of a bromide of carbon C^4Br^2. (M. Herma
Ch. Pharm. xcv. 211.)

CARBON, CHLORIDES OF. Carbon does not unite directly with
but several compounds of these elements are obtained by the action of chlor
by light or heat, on organic bodies, chiefly on hydrocarbons or their chlorin
vatives, *e. g.* CCl^4 from marsh-gas (CH^4), or chloroform ($CHCl^3$), C^2Cl^4 from
(C^2H^4), C^3Cl^6 from tritylene (C^3H^6), $C^{10}Cl^8$ from naphthalene ($C^{10}H^8$), &c.
tomary, however, to restrict the term chloride of carbon to four of the
containing 1 and 2 atoms of carbon, while the rest are regarded as substituti
tives of organic radicles, *e. g.* $C^{10}Cl^8$, as perchloronaphthalene. The names an
of these four compounds are given in the following table, in the left-hand co
cording to the atomic weight of carbon [12] here adopted, in the right-han
according to the smaller atomic weight of carbon [6], the latter being the
which they are generally known:

[C = 12]			[*C* = 6]	
Protochloride . .	C^2Cl^2	or	Subchloride . .	C^4Cl^2
Dichloride . . .	C^2Cl^4	„	Protochloride . .	C^4Cl^4
Trichloride . . .	C^2Cl^6	„	Sesquichloride .	C^4Cl^6
Tetrachloride . .	CCl^4	„	Di- or Bi-chloride .	C^2Cl^4

---

* C^2Br^6 has been recently obtained. See ETHYLENES, BROMINATED.

no real distinction between these four compounds and others formed
lements, excepting that they are of lower atomic weight, and that
ed from disulphide of carbon, the vapour of that substance mixed
passed through a hot tube yielding the tetrachloride, and the
roduced, either by exposing this compound to a higher temperature
reducing agents.

DE OF CARBON, CCl^4. *Dichloride or Bichloride of Carbon. Car-
chlorinated Chloride of Methyl. Perchloroformene.*—This compound,
ue of marsh-gas CH^4, and of carbonic anhydride CO^2, was disco-
lt in 1839 (Ann. Ch. Phys. [2] lxxi. 337). It is produced: 1. By
ine on marsh-gas (Dumas, Ann. Ch. Phys. [3] lxxiii. 95).—2. By
orine on chloroform in sunshine: $CHCl^3 + Cl^2 = HCl + CCl^4$.
ly heated in a retort exposed to the sun, and a stream of dry chlo-
ly and continuously through it, the liquid which distils over being
back till hydrochloric acid ceases to be evolved, after which the dis-
ith mercury to remove free chlorine, and then rectified (Regnault).
of chlorine on disulphide of carbon: $CS^2 + 4Cl^2 = CCl^4 + 2SCl^2$.
with vapour of sulphide of carbon by passing through the liquid is
gh a red-hot tube containing fragments of porcelain and connected
rounded with ice; and the yellowish-red mixture of tetrachloride of
le of sulphur thereby obtained is very slowly added to an excess of
of lime, the mixture being agitated from time to time and after-
Tetrachloride of carbon then passes over, sometimes mixed with
if too much of that compound was mixed with the chlorine, or if
trong enough; the sulphide of carbon may be removed by leaving
time in contact with potash-ley (Kolbe, Ann. Ch. Pharm. xlv. 41;
er (*ibid.* cvii. 212) removes the sulphide of carbon, by dissolving
hol, adding alcoholic potash as long as it thereby acquires a darker
the liquid gently to promote the conversion of the sulphide of carbon
tassium; then separates the unaltered chloride of carbon by water;
ashing.—4. By the action of pentachloride of antimony on disulphide

$$CS^2 + 2SbCl^5 = CCl^4 + 2SbCl^3 + S^2.$$

omes hot, and on cooling deposits crystals of trichloride of antimony
r, while tetrachloride of carbon remains in the liquid state. (Hof-
Qu. J. xiii. 65.)

rachloride of carbon is a thin transparent colourless oil, having a
odour. Specific gravity 1·56. Boiling point 77° C. Vapour-density
—5·33, representing a condensation to 2 vols. $\left(\frac{12 + 4 . 35·5}{2} \times\right.$
It is insoluble in water, but soluble in alcohol and in ether.

—Tetrachloride of carbon passed through a red-hot tube, is resolved
and a lower chloride of carbon, which, at a bright red heat is chiefly
gher temperature C^2Cl^2, and at a dull red heat, a body isomeric with
only half the vapour-density of that compound (Regnault).—
ith *hydrogen* and passed through a red-hot tube filled with pumice, it
nd ethylene (Berthelot, Ann. Ch. Phys. liii. 69; Jahresber. d.
9).—3. With *sulphuretted hydrogen*, in like manner, at a low red
rochloric acid and sulphochloride of carbon, $CCl^4 + H^2S = 2HCl +$
4. Dissolved in weak alcohol and treated with *amalgam of potas-*
art of its chlorine to the potassium, and yields chloroform, $CHCl^3$,
hloride of methyl, CH^2Cl^2, and marsh-gas (Regnault).—5. Treated
with an upright condensing tube with *zinc and dilute acid*, it yields
and chloroform, the latter being converted by the further reducing
ture, into a body containing still less chlorine, probably CH^2Cl^2
.)—6. It is not decomposed by aqueous potash or sulphydrate of
lcoholic potash slowly converts it into chloride and carbonate of
ault). Heated with alcoholic potash to 100° C. in a sealed tube
rtly converted into ethylene (Berthelot, Ann. Ch. Pharm. cix.
to 170° or 180° C. with 3 vols. *phenylamine*, it yields carbotri-
(Hofmann, Proc. Roy. Soc. ix. 284):

$$I^5) + CCl^4 = \underset{\text{Hydrochlorate of carbotriphenyltriamine.}}{[N^3.\overset{iv}{C}.(C^6H^5)^3.H^2].HCl} + \underset{\text{Hydrochlorate of Phenylamine.}}{3[(N.H^2.C^6H^5).HCl]}.$$

nine.

osphine it yields a white crystalline product. (Hofmann, *ibid.* x.

A compound, CCl^4SO^2, formed by the action of moist chlorine on sulphide
sometimes regarded as *sulphite of tetrachloride of carbon*, but more probab
nated derivative of *methyl-sulphurous acid*, will be described under that he

TRICHLORIDE OF CARBON. C^2Cl^6. *Sesquichloride of Carbon, Perchlor*
bon, Perchlorinated Chloride of Ethylene, Chlorure de Chloroxéthose.—This
which was discovered and investigated by **Faraday** (Phil. Trans. 1826,
further by **Regnault** (Ann. Ch. Phys. [2] lxix. 166; lxxxi. 371), is produ
action of chlorine in sunshine on various compounds and derivatives o
ethylene: 1. On dichloride of carbon, C^2Cl^4 (**Faraday**).—2. On chloride c
$C^2H^4Cl^2 + 4Cl^2 = 4HCl + C^2Cl^6$; the action also takes place, though mo
diffused daylight (**Faraday**), or with aid of heat (**Liebig**).—3. On chlori
first in the shade, afterwards in sunshine: $C^2H^5Cl + 5Cl^2 = 5HCl + C^2Cl^6$
Ann. Ch. Phys. [2] lxxxiv. 328); similarly on mono-, di-, or tri-chlorinated
ethyl (**Regnault**).—4. On sulphite of ethyl, with simultaneous formati
ride of sulphuryl, chloraldehyde, and hydrochloric acid (**Ebelmen** and
Ann. Ch. Phys. [3] xvii. 66):

$$(C^2H^5)^2SO^3 + 11Cl^2 = C^2Cl^6 + SO^2Cl^2 + C^2Cl^4O + 10HCl.$$

5. On oxide of ethyl, which, in bright sunshine, is sometimes converted
sesquichloride of carbon and chloraldehyde, sometimes into perchloret
$C^4Cl^{10}O$, 1 at. of which is resolved by distillation into C^2Cl^4O and C^2Cl^6 (
Malaguti). Several perchlorinated compound ethers (carbonic, succini
yield trichloride of carbon, when similarly treated.—6. On hydrochlora
lamine:

$$C^7H^7N + 5Cl^2 = C^2Cl^6 + NH^4Cl + 3HCl.$$

The sal-ammoniac is ultimately resolved by the excess of chlorine into h
acid and nitrogen, which escapes, a certain portion, being, however, converte
ride of nitrogen (**Geuther** and **Hofacker**, Ann. Ch. Pharm. cviii. 51). Th
of chloride of nitrogen must render the process dangerous.—7. Tetrachlorid
passed through a red-hot tube is resolved into the trichloride and free chlor

Preparation.—1. Chloride of ethylene is exposed to the sun in a bottle
chlorine, water being frequently added in small portions to absorb the h
acid produced, and the chlorine frequently renewed as long as any actio
tible. The crystalline product is washed with water, pressed between bib
heated to sublimation, then dissolved in alcohol, precipitated by water
potash, again washed with water, pressed, and dried in vacuo over sul
(**Faraday**). By passing chlorine through chloride of ethylene, heated n
boiling point, part of that compound is converted into trichloride of ca
crystallises out for the most part on cooling the liquid with ice (**Liebi**
Pharm. i. 219).—2. A bottle filled with chlorine, and containing a little
ethyl, is set aside in the shade for twenty-four hours, the chlorine then r
the vessel exposed to the sun: such exposure at the beginning of the pr
produce explosion (**Laurent**). Or better: vapour of chloride of ethyl produc
ing alcohol with strong hydrochloric acid, and purified by passing through
oil of vitriol, is brought in contact with chlorine in a vessel exposed to the
(**Regnault**).—3. Perchlorethylic oxide ($C^4Cl^{10}O$) is distilled, and the dist
peatedly treated with water, which takes up chloraldehyde and leaves tr
carbon. (**Malaguti**, Ann. Ch. Phys. [3] xvi. 6, 14.)

Properties.—Trichloride of carbon crystallises in right rhombic prism
dified by the faces $\infty \breve{P} \infty$ and the horizontal prism $P \infty$. Angles of the p
58° and 122° (**Brooke**); 59° and 121° (**Laurent**). The crystals are colo
sparent, and nearly tasteless, but have an aromatic camphorous odour.
hard as sugar, and easily pulverised. Specific gravity = 2·0. Refractin
1·5767. They do not conduct electricity. They melt at 160° C.; boil and
182°, and volatilise even at ordinary temperatures. Vapour-density = 8
sponding to 2 volumes $\left(\frac{2 \cdot 12 + 6 \cdot 35{\cdot}5}{2} \times 0{\cdot}0693 = 8{\cdot}212\right)$. Insoluble
soluble in alcohol, still more in ether; the solutions are not clouded by nitra
Soluble also in oils, both fixed and volatile.

Decompositions.—1. By repeated distillation, or by passing its vapour thr
hot porcelain tube, the trichloride is resolved into the dichloride, C^2Cl
chlorine.—2. It burns with a red light in the flame of a spirit-lamp, but is e
on removal.—3. Passed, together with *hydrogen*, through a red-hot tub
hydrochloric acid and dichloride of carbon (**Geuther**), and undergoes a
composition when heated with *sulphur*, *phosphorus*, or *iodine*.—4. Most *m*
in the vapour of the trichloride are converted into chlorides, with separati

our passed over red-hot *baryta, strontia,* or *lime,* yields a chloride
the metal, with deposition of charcoal; with *oxide of zinc,* it some-
loride of carbon; with the *oxides of copper* and *mercury,* and with
he products are metallic chloride and carbonic anhydride.—6. The
ltered by distillation with aqueous or alcoholic potash; but when
an alcoholic solution of *sulphydrate of potassium,* it yields dichlo-
ether with chloride of potassium, sulphydric acid, free sulphur, and
ompound, apparently resulting from a secondary action (Regnault):

$$C^2Cl^6 + 2KHS = C^2Cl^4 + 2KCl + H^2S + S.$$

d tubes with 8 at. *hydrate of potassium,* it yields oxalate and chloride

$$C^2Cl^6 + 8KHO = C^2K^2O^4 + 6KCl + 4H^2O;$$

tion is very imperfect, even when the mixture is heated to between
or several days (Geuther, Ann. Ch. Pharm. lx. 247).—8. Heated to
tubes with *alcoholic potash,* it yields the same products, together with
ethylene (Berthelot, Ann. Ch. Pharm. cix. 118). The principal re-
represented by the equation:

$$7KHO + C^2H^5.K.O = C^2K^2O^4 + 6KCl + 4H^2O + C^2H^4,$$

rogen results from a secondary decomposition, a number of liquid
n insoluble substances being formed at the same time. Trichloride
tacked by ammonia, nitric acid, or sulphuric acid. Boiling nitric
art separating on cooling, the rest on addition of water. In contact
water, it does not yield trichloracetic acid.

OF CARBON. C^2Cl^4. *Protochloride of Carbon, Perchlorethylene, Chlo-*
ed and examined by Faraday (Phil. Trans. 1821, p. 47), further by
Ch. Phys. [2] lxx. 104; lxxxi. 372). It is produced by the action of a
richloride or tetrachloride of carbon, either alone or in presence of
766); by the action of nascent hydrogen on the trichloride at ordinary
by that of alcoholic sulphydrate of potassium on the trichloride, and
on the tetrachloride (p. 765).

. Vapour of trichloride of carbon is passed through a red-hot tube filled
glass, whereupon a large quantity of chlorine is set free, and the di-
er in the form of a liquid coloured yellow by chlorine. It is purified
ral times through the red-hot tube, then shaking it up with mercury,
as low a temperature as possible (Faraday).—2. The trichloride is
rtions to an alcoholic solution of sulphydrate of potassium, and, as soon
sulphuretted hydrogen has ceased, the liquid is distilled, and the alco-
uted with water: the dichloride then separates in the form of a heavy
s is easier than the preceding (Regnault).—3. Trichloride of car-
water and granulated zinc, and sulphuric acid added from time to
n, till all the trichloride is decomposed. On subsequently distilling
ride of carbon passes over with the aqueous vapour. (Geuther,
cvii. 212.)

ry mobile liquid, of specific gravity 1·619 at 20° C. (Regnault),
uther). Refracting power = 1·4875 (Wollaston). It does not
y. It remains liquid at −18° C.; boils at 122° (Regnault), 116·7°
pour-density, by experiment = 5·82, corresponding to 2 volumes.
× 0·0693 = 5·75.) It is insoluble in water, acids, and aqueous al-
s in alcohol, ether, and oils, both fixed and volatile.

—1. At a red heat it is resolved into free chlorine and the proto-
2. When its vapour is passed over red-hot *baryta,* vivid ignition
formation of chloride of barium and carbonic anhydride, and separa-
-3. Heated for some time to 200° C., with 6 at. *hydrate of potassium,*
onverted into oxalate and chloride of potassium, with evolution of
uther, Ann. Ch. Pharm. cx. 247):

$$C^2Cl^4 + 6KHO = C^2K^2O^4 + 4KCl + 2H^2O + H^2.$$

chlorine in sunshine, forming the trichloride, C^2Cl^6; but if exposed
of chlorine under a layer of water, it yields trichloracetic acid.
. Pharm. liv. 181):

$$C^2Cl^4 + 2H^2O + Cl^2 = C^2HCl^3O^2 + 3HCl.$$

nine in sunshine, yielding chlorobromide of carbon, $C^2Cl^4Br^2$.

PROTOCHLORIDE OF CARBON, C^2Cl^2. *Subchloride of Carbon, Julin's* *Carbon.*—This compound was discovered in 1821, by Julin, a manufacture acid at Abo in Finland, who obtained it accidentally in distilling crude nitre green vitriol in cast-iron retorts, the cast-iron probably furnishing the carbo crude nitre the chlorine (Ann. Ch. Phys. [2] xviii. 269). It was more e vestigated by **Phillips** and **Faraday** (Phil. Trans. 1821), and afterward **nault** (Ann. Ch. Phys. [2] lxx. 104), who prepared it by passing vapour of or of dichloride of carbon, through a strongly ignited porcelain tube filled ments of porcelain, dissolving the crystalline product in ether, filtering, evap dryness, and subliming. In performing this process, care must be taken the porcelain tube too strongly; otherwise, no chloride of carbon will be obt only a deposit of charcoal.

Properties.—Protochloride of carbon forms white, delicate needles, appare sided, having a silky lustre. It melts, boils, and sublimes between 175° an but may be sublimed without fusion at 120°, the sublimate then consisti needles. It has a peculiar odour, something like that of spermaceti, but no the cold it is almost inodorous. It is insoluble in water, but very soluble i dissolves also in ether, and in hot oil of turpentine, whence it crystallises on cooling.

The alcoholic solution does not precipitate nitrate of silver.

The vapour passed through a red-hot porcelain tube filled with fragment crystal, is resolved into chlorine and charcoal. The compound burns with bl in the flame of a candle, but ceases to burn when withdrawn. It is not d or dissolved by nitric, hydrochloric, or sulphuric acid, or by boiling potash. does not act upon it, even in sunshine. Potassium burns in its vapour wi ignition, forming chloride of potassium and depositing charcoal.

Berthelot regards this compound, not as C^2Cl^2, but as $C^{10}Cl^{10}$. The vapo does not appear to have been determined.

CARBON, CHLOROBROMIDE OF. $C^2Cl^4Br^2$. *Bromide of Perch* *Bromure de Chloroxéthose.* (**Malaguti**, Ann. Ch. Phys. [3] xvi. 14.)—Di carbon exposed to sunshine in contact with bromine solidifies in a few hours talline mass, which may be purified by repeated crystallisation from alcohol. tals resemble those of C^2Cl^6; they have a specific gravity of 2·3 at 21° C., tas aromatic, begin to volatilise at 100°, decompose at about 200° into bromine chloride, and when treated with protosulphide of potassium are resolved in of potassium and dichloride of carbon:

$$C^2Cl^4Br^2 + K^2S = C^2Cl^4 + 2KBr + S.$$

CARBON, DETECTION AND ESTIMATION OF. The meth tecting and estimating carbon and its compounds have been already described head of ANALYSIS.

If the carbon is not already in the form of carbonic anhydride or a carbo converted into carbonic anhydride by combustion, either in an atmosphere o with oxide of copper or chromate of lead, the amount of carbonic anhydride th duced being estimated by absorption in strong potash-ley (ANALYSIS, ORGAN —238). This method serves for the estimation of carbon in cast-iron and oth compounds, as well as in organic bodies. *Gaseous carbon-compounds*, such oxide and hydrocarbons, are converted into carbonic anhydride by explosio cess of oxygen, the amount of that compound produced being then dete absorption with potash. (ANALYSIS, VOLUMETRIC, OF GASES, pp. 286—288

Carbonates are decomposed with dilute sulphuric or hydrochloric acid, a bonic anhydride thereby evolved is usually determined by loss (see ACIDIM and ALKALIMETRY, p. 149). The presence of carbonates in any mixture, solid is detected by the effervescence which ensues on addition of dilute sulphuric chloric acid. This effervescence may, however, arise from the escape of acid or sulphurous anhydride, if sulphides or sulphites are also present. T are readily distinguished from carbonic anhydride by their peculiar odours; acid also by its property of blackening lead-salts. To detect carbonic anhyd evolved together with one or both of these gases, the gaseous mixture is baryta-water. If a precipitate is formed, carbonic or sulphurous acid may or both; if the former alone, the precipitate will be completely soluble in h acid, *after treatment with chlorine-water;* but if sulphurous acid is also pres be oxidised by the chlorine-water, and converted into sulphuric acid, which form sulphate of barium, insoluble in hydrochloric acid.

The amount of carbonic anhydride in a gaseous mixture is ascertained absorption with potash, sulphurous anhydride or sulphydric acid, if prese been previously removed by absorption with peroxide of manganese (p. 282)

n solution, either free or combined, in a mineral water for example,
ding ammonia and chloride of calcium, and leaving the liquid to
ask for several hours. The carbonic acid is thereby precipitated as
m, containing 43·88 per cent. CO^2.

carbonic acid in the air, a large quantity of air, the volume being
pirator (p. 427), is passed through a series of weighed potash-bulbs.
to shake up a quantity of air in a closed vessel of known capacity,
ime-water of known strength, and then determine the quantity of
combined by means of a standard solution of oxalic acid. This
execution, and affords the means of quickly determining the varying
c acid in the several parts of an inhabited apartment at different

t of Carbon.—Three methods have been adopted for determining
of carbon: 1. From the quantity of carbonic anhydride produced
of a given weight of carbon.—2. By comparing the weights of equal
c anhydride and oxygen, it being supposed that carbonic anhydride
olume of oxygen.—3. From the weight of metallic silver obtained
of organic silver-salts.

ls the first is considered the most trustworthy. The amount of car-
oduced by the combustion of carbon was determined with a very
n to the truth by Lavoisier in 1775, afterwards with more or less
n-Morveau (1785), Clément and Desormes (1802), Allen and Pepys
ure (1809); but the most exact determinations are those made by
s (Ann. Ch. Phys. [3] i. 1), and by Erdmann and Marchand
. 159). These chemists burned weighed quantities of diamond or
le of copper and oxygen gas, and weighed the carbonic anhydride
tash-apparatus, after it had been freed from a very small quantity
by passing over chloride of calcium or sulphuric acid. The small
l ash was deducted from the weight of the carbon employed, and
ter produced in the combustion likewise taken into account.

the quantity of carbon which combines with 200 pts. of oxygen to
ydride was found by Dumas and Stas, in fourteen experiments, to
he limits 74·87 and 75·12, the mean result being 75·005, with a pro-
·013. Erdmann and Marchand, in nine experiments similarly con-
umbers varying between 74·84 and 75·19, the mean being 75·028. Now
xides of carbon, carbonic anhydride contains, with the same quantity
much oxygen as carbonic oxide, these compounds may be represented
$)^2$ and CO, a view of their constitution, which is likewise in accord-
he other compounds of carbon. Hence, from the above-mentioned
the composition of carbonic anhydride, it follows that if the atomic
= 100, that of carbon will be 75, and on the hydrogen scale:

If O = 8, C = 6
and if O = 16, C = 12.

pting the numbers in the last line are fully detailed in the article
(pp. 459—462).

hod of determining the atomic weight of carbon was first adopted by
ong in 1819. From specific gravity determinations then made it
t equal volumes of carbonic anhydride and oxygen weighed 1·5425
tively; and assuming that carbonic anhydride contained its own
the difference of the two numbers gave the weight of the carbon in
whence it was calculated that the atomic weight of carbon on the
= 100) was 76·528, which number was adopted as correct for twenty
Vrede, following the same method, but taking into account the more
of expansion of the gases determined by Rudberg, Magnus, and
l the number 75·12. Determinations not much differing from this
manner by other experimenters; but the method is not capable of
ct results, because the alterations of volume sustained by oxygen
dride for equal variations of temperature and pressure are not equal,
he assumption that oxygen, in being converted into carbonic anhy-
o change of volume, cannot be true for all temperatures.

od, founded on the analysis of the silver-salts of organic acids, was
g and Redtenbacher (Ann. Ch. Pharm. xxxviii. 116). Assuming
l = 12·48 (O = 100), these chemists obtained as the mean result of
= 75·854. The more exact determinations since made of the atomic
ould lead to a slight alteration in this result. Strecker, from the

same experiments, and without assuming the atomic weights of silver a known, calculated the atomic weight of carbon as = 75·416; but this met as the second, is not considered so trustworthy as the first, the result of tained by Dumas and Stas is now universally adopted.

CARBON, IODIDE OF. No compound of carbon and iodine has y tained. Iodoform, CHI^3, was formerly supposed to be an iodide of carbon, t contained in it having been overlooked. (Gm. vii. 335.)

CARBON, NITRIDE OF. Only one compound of carbon and known with certainty, viz. CYANOGEN, CN (*q. v.*) Many cyanogen-compou calcination a residue called mellone, which Liebig regards as a nitride of taining C^3N^4. It does not, however, appear to have been obtained quit hydrogen (see MELLONE and MELLONIDES). According to Thaulow, a pec of carbon, isomeric, but not identical with cyanogen, is obtained by ignitio of silver (see CARBAZOTE, p. 757).

CARBON, OXIDES OF. Two oxides of carbon are known, the pr and the dioxide, or carbonic anhydride, CO^2, commonly called *carbonic acid* produced by the direct combination of carbon and oxygen; the former is in the gaseous state: the latter is gaseous at ordinary temperatures.

DIOXIDE OF CARBON. CARBONIC ANHYDRIDE, CO^2. *Anhydro acid, Fixed air, Mephitic air, kohlensaures gas, Kohlensäure, Gas sylvest sylvestris.*—The evolution of this gas in the burning of lime and in ferme known to Paracelsus and Van Helmont, the latter of whom gave it the *sylvestre;* its properties were afterwards investigated by Hales, Black, Priestley, and Bergmann, but its true composition was first demonstrated b who showed that it was a compound of carbon and oxygen, containing carbon and 72 oxygen, numbers approaching very nearly to the proportions as correct, viz. 27·27 carbon to 72·73 oxygen (p. 769).

Carbonic anhydride is formed by the combustion of carbon in oxygen g air. It is a constant product of the ordinary processes of combustion, ina substances used for fuel, such as wood, coal, oil, wax, tallow, &c. contain ca likewise formed by the respiration of animals, in various processes of ferm in the preparation of wine and beer, and by the decay of animal and ve stances. It issues from fissures in the ground, in various localities, chiefl districts, and is ejected in enormous quantities from the craters of acti From all these sources it is continually being poured into the atmosphere, therefore forms a constant constituent: the average amount of it containe in the open country, is 4 volumes in 10,000; in the air of crowded town much greater (p. 437). It exists also in larger proportion at the bottom of quarries, and caverns, especially in limestone districts, where it is e fissures and does not readily escape, in consequence of its greater density anhydride (or acid), exists also in solution in all natural waters, some, Seltz, Vichy, and Spa, containing it in such quantity as to give them an character. Lastly, it is produced by the decomposition of carbonates, eithe by the action of the stronger acids, and is a frequent product of the deco organic bodies at high temperatures.

Preparation.—The easiest way of obtaining the gas is to decompose chal with hydrochloric acid, in an ordinary generating vessel, provided with a tube:

$$Ca''CO^3 + 2HCl = Ca''Cl^2 + CO^2 + H^2O.$$

Dilute sulphuric acid may also be used, but it is less convenient, as the calcium produced forms a hard mass in the vessel, which is difficult to ext chloride of calcium is easily soluble: moreover, the chloride is more use dual product. The gas may be received over water, or, as it is very heav collected by simple displacement of the air, the delivery-tube being ben downwards, so as to reach to the bottom of the receiver. This is al convenient mode of collection when the gas is required dry, a desiccating t ing dry chloride of calcium or pumice-stone soaked in oil of vitriol, bein between the generator and receiver. On the large scale, carbonic anhyd obtained by heating chalk or marble to redness, in an iron or earthen reto

Properties.—Carbonic anhydride is, at ordinary temperatures and pressur less gas, but may be liquefied by cold or pressure (p. 771). Its specific gr gaseous state is 1·5241 (Regnault), being rather more than 1½ times that consequence of this great density, it may be poured from one vessel to ano liquid, and often collects at the bottom of wells, mines, and caverns, as in *del Cane* near Naples, the atmosphere of which, within about a foot of the highly charged with the gas, while the upper part is comparatively free.

From the experiments of Regnault, it appears that the density of carbonic

in the same proportion as the pressure, excepting within narrow limits:
re of several atmospheres, the deviation from this law is very perceptible.
of expansion by heat between 0° and 100° C. is 0·3719 (Regnault;
gnus); refracting power = 1·526 (Dulong).
hydride does not affect the colour of *litmus-paper*, when both are quite
oisture is present, the blue colour of the paper changes to wine-red,
iced by boric acid: on exposure to the air, however, the redness disap-
quence of the escape of the gas. *Lime-water* introduced into the gas is
endered turbid, in consequence of the formation of neutral carbonate of
an excess of the gas is present, the liquid becomes clear again after a
ly if shaken, an acid carbonate being then formed, which is soluble in
on of *potash*, or a lump of moist solid potash, introduced into the gas
mercury, rapidly absorbs it. It dissolves in about its own volume of
ary temperatures, and in less than $\frac{1}{5}$ of its volume of *alcohol*.
hydride is irrespirable; animals immersed in it soon die, not only from
n, but in consequence of a direct poisonous action, violent spasms being
duced, sometimes complete atony of the cerebral faculties. Mixed with
es from effervescing liquids, it produces a pungent sensation in the n-
ns, but it cannot be said to have any decided odour. It is incombustible,
ely extinguishes a burning taper, also the flame of sulphur or phosphorus:
heated to redness in the dry gas, decomposes it completely, burning with
nd producing a deposit of charcoal mixed with carbonate of potassium.
poses it in like manner, but without becoming red-hot. *Phosphorus* and
nce of an alkali, likewise abstract all the oxygen at a red heat. *Hy-*
al, *iron*, and *zinc*, at a red heat, abstract half the oxygen, converting
nhydride into carbonic oxide. It is also resolved into carbonic oxide and
passage of electric sparks, if hydrogen gas, mercury, or some other
nt to take up the oxygen; otherwise, the spark immediately causes the
nbine. *Growing plants*, or the leaves and other green parts separated
t, but still in the fresh state, decompose carbonic anhydride completely
ence of daylight, and more rapidly in direct sunshine, abstracting the
carbon, and setting the oxygen free. If some fresh leaves of any plant
n inverted receiver, filled with water containing carbonic acid, and stand-
r, and the whole be exposed to the sun, a considerable quantity of
ill collect at the top of the receiver in a few hours. This action of
is the chief cause which prevents the continual accumulation of car-
de in the atmosphere, and keeps the proportion of it nearly constant.
ERE, p. 438.)
the mode of determining the composition of carbonic anhydride, see
ensity corresponds to 2 volumes of vapour:

$$\frac{12 + 2 . 16}{2} \times 0·0693 = 22 \times 0·0693 = [illegible]$$

es and temperatures considerably above its liquefying point, it contains
xygen exactly equal to its own.
onic Anhydride.—Carbonic anhydride passes to the liquid state at [illegible]
re of 36 atmospheres. Fa [illegible] the liquefaction by evolving the
onat [illegible] ammonia, by th [illegible] sealed tube (see
[illegible] but the me [illegible] small quantity,
er obtain [illegible] by the method of
arm. xx [illegible] two very strong
ling 6 [illegible] better, of lead
d str [illegible] they rest by
uld [illegible] so that they may
ull- [illegible] afterwards. Into
[illegible] of sodium, and
[illegible] and a copper tube
[illegible] likewise introduced
[illegible] of peculiar con-
[illegible] with the carbonate
[illegible]

bonic anhydride distils over from the first, which is still warm, and condenses i liquid state. After about a minute the cocks are closed, the cylinders separated charge in the first renewed; and this series of operations is repeated several time the second cylinder is about two-thirds filled with liquid carbonic anhydride.

Liquid carbonic anhydride is colourless and very soluble in alcohol, ether, and tile oils, but does not mix with water. Specific gravity 0·90 at −20° C.; 0· 0° C.; 0·60 at + 30° C. (Thilorier). Its tension at different temperatures is a in the following table.

Temp. C.	Tension in Atmospheres.		Temp. C.	Tension in Atmospheres.	
	Faraday.	Mareska and Donny.		Faraday.	Mareska and Donny.
−59·4°	4·6		−5·0°	33·1	36
48·8	7·7		0·0	38·5	42
36·6	12·5		+6·3		46
30.5	15·4		10·0		52
26·1	17·8		15·5		57
20·0	21·5	23·6	19·0		63
15·0	24·7	25·3	23·5		68
12·2	26·8		27·0		74
10·0		27·5	30·7		80
9·4	29·1		34·5		

Solid Carbonic Anhydride.—When the liquid anhydride is suddenly relieved the pressure under which alone it can exist, part of it flashes instantly into va and in so doing produces so great a degree of cold, that the remaining portion of the solidifies. To obtain the solid anhydride, the receiver containing the liquid is pro with a tube passing through its side, and reaching nearly to the opposite side, s when the cylinder is set horizontally, this tube dips into the liquid. On open stopcock provided for the purpose, a quantity of the liquid is forced out by the pre of the gas above it, and forms a white cloud of the solid anhydride, as it issue the air. By causing this jet of vapour to pass into a cylindrical metal box, b within it an inclined metal tongue, against which the jet of liquid and vapou pinges, and is thus made to circulate within the box for some little time be finally escapes, a considerable quantity of the solid anhydride may be collected form of a white flocculent mass like snow.

Solid carbonic anhydride may be left exposed to the air for some little time w evaporating, because, like all flocculent substances, it conducts heat but slowly. tension is 1·14 atmospheres at −99·4° C.; 1·36 at −77·2°; 2·28 at −70·5°; −63·2°; 4·6 at −59·4°; 5·33 at −57·0 (Faraday). An air or spirit thermo immersed in it sinks to −78° C. Notwithstanding this low temperature, the substance may be placed on the hand without occasioning a very acute sensati cold, because it does not come into close contact with the skin, being separated it by a film of vapour; but if pressed between the fingers, it produces a very p sensation, and raises a blister like a burn. By mixing it with ether, its heat-co ing power is greatly increased; it therefore evaporates more quickly, and pr much more powerful frigorific effects. Mercury poured into it solidifies instantl mass like lead. The cold which it produces is sufficient to liquefy sulphydric chlorine, nitrous oxide, and several other gases. The intensity of the cold may further increased by placing the mixture under an exhausted receiver. The rature then sinks to a degree at which the liquid anhydride is not more volatil water at 30° C., and alcohol assumes the consistence of a thick oil, but does not so By exposing to this bath, tubes of glass or copper in which gases have been comp by a forcing pump to 40 atmospheres, Faraday has succeeded in liquefying known gases, excepting oxygen, hydrogen, nitric oxide, carbonic oxide, and mar and in solidifying a considerable number of them. Carbonic anhydride itself e to this temperature and pressure, is reduced to a vitreous transparent mass.

Carbonic Acid.—Gaseous carbonic anhydride dissolves in about its own v of water at ordinary temperatures, forming a solution of specific gravity 1·001 has a sharp and slightly acid taste, turns the blue colour of litmus to wine-red, pa neutralises alkalis, and dissolves the carbonates of barium, strontium, calcium, nesium, &c. It, therefore, possesses *acid* properties, and from the composition carbonates, we may infer that it contains an acid of the composition H^2CO^3. B acid cannot be isolated, as heat, diminished pressure, or congelation immediat solves it into water and carbonic anhydride. In short, carbonic acid as a d compound cannot be said to be known.

of carbonic anhydride dissolved by water at a given temperature, is
e under all pressures; consequently the weight of the gas absorbed in-
rly the same proportion as the pressure. This rule must not, however,
as strictly true, for Regnault has shown that the volume of carbonic
not vary exactly in the inverse ratio of the pressure.

ven pressure, the volume of gas absorbed diminishes as the temperature
boiling heat, the whole of the gas is driven off; hence carbonic acid
an earthy carbonate in solution deposits it when the liquid is boiled.
use of the furring of kettles, boilers, &c., in which spring or river-water
bonate of calcium dissolved in this manner, is boiled.

ients of absorption of carbonic anhydride, that is to say the volumes
C. and 0·760 met.) which 1 vol. of water absorbs under the pressure of
d at various temperatures, are as follows:

Vol. of Gas absorbed.	Temp.	Vol. of Gas absorbed.
. . . 1·7697	12° C. . . .	1·1018
. . . 1·6481	14 . . .	1·0321
. . . 1·5126	16 . . .	0·9753
. . . 1·3901	18 . . .	0·9318
. . . 1·2809	20 . . .	0·9013
. . . 1·1847		

ometry. See also the article GASES, ABSORPTION OF.)

h has been saturated with carbonic acid under pressure, gives it up with
ence as soon as the pressure is removed. The various kinds of aërated
ater, *effervescing lemonade*, &c., consist of water impregnated by mecha-
with large quantities of carbonic acid, and flavoured with various saline
redients. (For a description and figure of Tylor's soda-water machine,
ctionary of Arts, Manufactures and Mines, iv. 728.) Champagne and
cing wines and bottled beer likewise owe their sparkling properties to
f this gas; but in these liquids the carbonic acid is produced by the
tself, the wine or beer being bottled before the fermentation is complete,
siderable quantity of the gas, which would otherwise escape into the air,

haviour of aqueous carbonic acid to bases, see CARBONATES.

DE OF CARBON. CARBONIC OXIDE. CO.—This compound, which is
the gaseous state, was discovered towards the end of the last century by
by Priestley; but its true nature was first recognised some years after-
odhouse (Gilbert's Annalen, ix. 423). It is produced: 1. By the oxi-
on at very high temperatures, when the supply of oxygen is not sufficient
ete conversion of the carbon into carbonic anhydride (p. 763).—2. When
dride is exposed to a red heat in contact with hydrogen, carbon, metals,
s which can abstract part of the oxygen: hence it is always produced in
ke fires, when the draught of air has to pass upwards through a con-
s of red-hot fuel, and is the cause of the blue flame almost always seen
such fires.—3. It is also formed, together with hydrogen and carbonic
hen vapour of water is passed over red-hot coke or charcoal. A sample
mixture thus formed was found by Bunsen to contain 56·03 volumes per
gen, 29·15 carbonic oxide, 14·65 carbonic anhydride, and 0·17 carburetted
. Carbonic oxide is produced, either alone or together with carbonic
the reduction of metallic oxides by carbon at a strong red heat. The
om iron blast-furnaces contains from 25 to 32 per cent., that from copper-
ces from 13 to 19 per cent. carbonic oxide (Bunsen, Pogg. Ann. xlvi.
-5. In the dry distillation of many organic compounds.—6. In the de-
f oxalic acid and formic acid by strong sulphuric acid:

$$C^2H^2O^4 = CO + CO^2 + H^2O$$

Oxalic acid.

$$CH^2O^2 = CO + H^2O$$

Formic acid.

omposition of crystallised ferrocyanide of potassium by sulphuric acid

$$3H^2O + 6H^2SO^4 + 3H^2O = 6CO + 3(NH^4)^2SO^4 + 2K^2SO^4 + Fe''SO^4$$

erro- f . Sulphate of ammonium. Sulphate of potassium. Ferrous sulphate.

Preparation. — 1. By heating to redness in a gun-barrel fitted with a gas-deli
tube, a mixture of oxide of iron, zinc, lead, or copper with charcoal or graphite ;
an alkaline or earthy carbonate (chalk for example) with graphite, charcoal, or
filings; or by passing carbonic anhydride repeatedly over red-hot iron or char
By either of these methods, carbonic oxide is obtained mixed with carbonic anhyd
from which it may be freed by passing the gas through milk of lime or strong pot
it may then be collected over water. The charcoal used must be previously well ig
to free it from moisture and absorbed gases.—2. By heating in a flask a mixtu
oxalic acid, or an oxalate, or a formate, with excess of strong sulphuric acid, and re
ing the carbonic anhydride evolved when oxalic acid or an oxalate is used, as befo
3. When crystallised ferrocyanide of potassium, in the state of powder, is heated
flask with eight or ten times its volume of sulphuric acid, carbonic oxide is evo
quite free from carbonic anhydride, and mixed only with a small quantity of va
of hydrocyanic acid, resulting from another reaction which takes place at the
time, if the quantity of water present is more than sufficient for the above decom
tion (see FERROCYANIDES). This is the most convenient mode of preparing car
oxide. Care must, however, be taken not to raise the heat higher than is neces
for the complete liquefaction of the mixture; for at that point the evolution of car
oxide ceases, and if the heating be continued, the excess of sulphuric acid acts o
ferrous sulphate produced, converting it into ferric sulphate, and being itself red
to sulphurous anhydride, which escapes as gas and mixes with the carbonic oxide

Properties.—Carbonic oxide is a colourless gas of specific gravity 0·96799 (Wre
its molecule CO therefore occupies two volumes:

$$\frac{12 + 16}{2} \times 0·0693 = 14 \times 0·0693 = 0·9702.$$

It is perfectly neutral to vegetable colours, and very sparingly soluble in w
which, according to Bunsen, dissolves only 0·024 or about $\frac{1}{40}$ of its bulk at 15° C.
is a very poisonous gas, acting chiefly on the nervous system, causing giddiness
inhaled, sometimes also acute pain in various parts of the body, and after a
complete asphyxia. According to Leblanc (Ann. Ch. Phys. [3] v. 223), it i
this gas that the suffocating quality of air in which charcoal has been burnt is ch
due.

Carbonic oxide does not support the combustion of bodies which burn in oxy
but in contact with the air it takes fire on the approach of a burning body, and b
with a blue flame, producing carbonic anhydride. Mixed with excess of oxyge
may be exploded by the electric spark, 2 vols. of it then uniting with 1 vol. ox
and producing 2 vol. carbonic anhydride CO^2. Now as 2 vols. CO^2 contain 2
oxygen, it follows that 1 vol. oxygen must have been derived from the carbonic o
Hence carbonic oxide contains half its own volume of oxygen. Now the weigh
2 vols. carbonic oxide, compared with hydrogen, is 28, which, diminished by 16,
weight of 1 vol. oxygen, leaves 12 for the weight of 1 atom of carbon. Hence in carb
oxide the same weight of carbon is united with exactly half as much oxygen a
carbonic anhydride.

The combustion of carbonic oxide may be brought about by contact with *platin*
A wire or foil of the metal requires to be heated to 300° C. to induce the combust
spongy platinum acts at ordinary temperatures, without becoming sensibly hea
but platinum-black introduced into the mixture of carbonic oxide and oxygen bec
red-hot and produces explosion.

Carbonic oxide reduces certain metallic oxides at a red heat, viz. the oxides of cop
lead, tin, iron, &c. It plays indeed an important part in the smelting of many me
especially of iron.

Carbonic oxide is rapidly absorbed by a solution of *cuprous chloride* in hydrochl
acid, also by ammonical solutions of cuprous salts. This reaction affords an excel
method of removing carbonic oxide from a gaseous mixture (p. 283). It red
gold from the neutral solution of its chloride without the aid of heat.

Carbonic oxide unites directly with *chlorine*, forming oxychloride of carbon or ph
gene gas; also with *potassium*. (See POTASSIUM.)

It is absorbed by *hot hydrate of potassium*, yielding formate of potassi
$CO + KHO = CHKO^2$. (Berthelot, Ann. Ch. Pharm. xcvii. 125.)

CARBON, OXYCHLORIDE OF. $COCl^2$ or *Chloride of Carbonyl* $(CO)''$
Chlorocarbonic oxide. Chlorocarbonic acid. Phosgene.—This compound was discov
by J. Davy (Phil. Trans. 1812, p. 144), who obtained it by exposing to the sun's
a mixture of equal volumes of chlorine and carbonic oxide. The mixture gradu
becomes colourless and contracts to half its original volume. The same action

n diffused daylight; none whatever in the dark. The name phosgene n to the gas signifies a compound formed by light.

of carbon may be more conveniently prepared by passing carbonic ling pentachloride of antimony, that compound being at the same time chloride. The gas must be received over mercury, as water decomposes , Ann. Ch. Pharm. lxx. 139). It is likewise produced when carbonic d over red-hot chloride of lead or chloride of silver, and in the following s of organic bodies:

ry distillation of trichloracetates:

$$C^2Cl^3MO^2 = COCl^2 + CO + MCl.$$

ry distillation of certain perchlorinated methylic ethers, *e. g.* of the *for-* = 2COCl²; and of the *oxalate*, $C^4Cl^6O^4 = COCl^2 + 3CO$.

ction of a large excess of strong sulphuric acid on the so-called sulphite e of carbon (p. 766):

$$CCl^4SO^2 + H^2O = COCl^2 + 2HCl + SO^3.$$

of carbon is a colourless gas having a suffocating and tear-exciting ecific gravity is 3·6808 (Davy), 3·4249 (Thomson); calculated for a o two volumes, it is

$$\frac{12 + 16 + 2 . 35{\cdot}5}{2} \times 0{\cdot}0693 = 3{\cdot}430.$$

g power is 3·936. It reddens moistened litmus-paper; does not fume

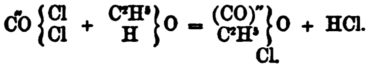
of carbon is decomposed by *water*, yielding carbonic anhydride and cid:

$$COCl^2 + H^2O = CO^2 + 2HCl.$$

d with an equal volume of hydrogen and half its volume of oxygen, it ntly on the passage of an electric spark, yielding the same products. ygen or hydrogen alone, it is not exploded by the electric spark.

antimony heated in the gas take up the chlorine, and leave carbonic oxide e to the original gas. Many metallic oxides, *oxide of zinc*, for example, with the aid of heat, forming a chloride of the metal and carbonic an- in volume to the original gas. *Trioxide* of antimony produces tri entoxide or tetroxide of antimony, leaving carbonic oxide.

it is converted into chlorocarbonic ethers, *e. g.*:



$$\overset{\prime\prime}{C}O\left\{\begin{matrix}Cl\\Cl\end{matrix}\right. + \left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O = \left.\begin{matrix}(CO)''\\C^2H^5\end{matrix}\right\}O + HCl.\ \ Cl$$

nia gas, oxychloride of carbon produces carbamide (p. 752) and chloride With *phenylamine* and many other organic bases, it reacts in like man- ubstitution-derivatives of carbamide.

, **SULPHIDES OF.** Only one of these compounds is known with the disulphide corresponding to carbonic anhydride. The formation of le, analogous to carbonic oxide, was announced, in 1857, by Baudrimont, ents have not been confirmed. (See page 777.)

DE OF CARBON. CS². *Bisulphide of Carbon, Sulphocarbonic Acid.* , Gehlen's N. allg. Journ. d. Chem. ii. 192; Clément and Desormes, lii. 121; Vauquelin and Robiquet, *ibid.* lxi. 145; Berthollet, d Vauquelin, *ibid.* lxxii. 252; Berzelius and Marcet, Schw. J. ix. ius, Gilb. Ann. xlviii. 177; Pogg. Ann. vi. 144; Zeise, Schw. J. xxvi.); xliii. 160; Couerbe, Ann. Ch. Phys. [2] lxi. 225; Kolbe, Ann. Ch. 3; xlix. 143; Pelouze and Frémy, *Traité de Chimie*, 4ᵐᵉ éd. i. 923).— d, which was discovered by Lampadius in 1796, is produced by the ation of sulphur and carbon at high temperatures, and in the decomposi- organic compounds. Sulphur and carbon do not combine when simply er in the solid state, because the sulphur volatilises before the requisite s attained; but if charcoal be heated to redness and sulphur-vapour the carbon burns in that vapour, forming CS².

g small quantities of the disulphide, a porcelain tube is filled with frag- coal, and inserted in an inclined position through a furnace having holes The upper extremity of the tube is closed with a cork, and the lower is bent glass tube, with a bottle containing water, the lower end of the bent hrough the cork and dipping just below the surface of the water. When the charcoal is red-hot, the upper end of the tube is opened and a piece of sulphur put in; the sulphur melts and runs down to the lower part of the tube, where it volatilises and combines with the carbon, forming disulphide of carbon, which passes off in vapour and condenses in the liquid form at the bottom of the water. For larger quantities, a tubulated earthen retort is used, having a porcelain tube passing through the tubulus, and reaching nearly to the bottom. The retort is filled with charcoal, heated to redness in a furnace, and bits of sulphur dropt in through the tube. The neck of the retort is connected with a condensing tube kept cold by a stream of water, and passing into a receiver containing cold water as above described. The sulphide of carbon which collects at the bottom of the water is not pure, but contains excess of sulphur. It is purified by distillation at the heat of the water-bath, the sulphide of carbon then volatilising and the sulphur remaining behind.

Properties.—Disulphide of carbon is a colourless, very mobile, strongly refracting liquid, having a faint and peculiarly unpleasant odour. Its refracting power is 1·645. Specific gravity 1·293 at 0° C., and 1·271 at 15°. Boils at 46·6° under ordinary pressure, and evaporates quickly at ordinary temperatures, producing great cold. Vapour-density = 2·67, corresponding to 2 vols. $\left(\frac{12 + 2 . 32}{2} \times 0·0623 = 2·63\right)$. It is insoluble in *water*, to which, however, it imparts its odour. *Alcohol* and *ether* mix with it in all proportions. It dissolves *sulphur*, *phosphorus*, and *iodine;* sulphur and phosphorus separate from it by spontaneous evaporation in well defined crystals. It dissolves *camphor* and mixes easily with *oils*, both fixed and volatile.

Decompositions.—1. Disulphide of carbon is very inflammable, and burns with a blue flame, producing sulphurous and carbonic anhydrides.—2. The vapour passed over various *metallic oxides* at a red heat, yields the same gaseous products, together with a metallic sulphide; the sulphides thus formed are generally crystallised, and resemble those found in nature. Sulphide of carbon is indeed one of the most powerful sulphurising agents known, affording the means of producing several metallic sulphides not otherwise obtainable (Frémy). It likewise converts oxides into sulphides when heated with them in sealed tubes; with *water* at 150° C. it yields carbonic anhydride and sulphydric acid (Schlagdenhauffen, J. Pharm. [3] xxix. 401).—3. The vapour is strongly attacked by *nitric acid*, yielding sulphuric acid and nitrous vapours. —4. Sulphide of carbon heated with *chlorates* or *hypochlorites* reduces them to chlorides, with evolution of carbonic anhydride and deposition of sulphur.—5. Heated with aqueous *iodic acid* in a sealed tube, it yields hydriodic acid, together with free iodine and a deposit of sulphur, also sulphuric acid, sulphydric acid, and carbonic anhydride. Two reactions appear to go on at once, viz.:

$$2HIO^3 + CS^2 = I^2 + CO^2 + H^2SO^4 + S.$$
$$2HIO^3 + 2CS^2 + 2H^2O = 2CO^2 + 2HI + H^2SO^4 + H^2S + S^2.$$

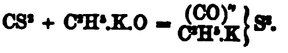
The liquid is at first coloured violet by the free iodine, but on increasing the heat, the colour disappears, in consequence of the action of the sulphydric acid on the iodine, which produces hydriodic acid and free sulphur, the latter imparting a straw-yellow colour to the liquid (Pelouze and Frémy).—6. *Bromic acid* acts in like manner.—7. Many *metals* decompose disulphide of carbon at a red-heat, taking up the sulphur and setting the carbon free.—8. A mixture of sulphide of carbon vapour and *sulphydric acid gas* passed over *red-hot copper* yields sulphide of copper and marsh-gas (Berthelot):

$$CS^2 + 2H^2S + Cu^4 = 4CuS + CH^4.$$

9. With *nascent hydrogen*, sulphide of carbon yields sulphydric acid, a crystallised body, CH^2S, and an oily substance not yet examined (Girard, Compt. rend. xliii. 391). —10. Dry *chlorine* converts it at a red heat into tetrachloride of carbon; at ordinary temperatures, into sulphochloride of carbon, $CSCl^2$; but with moist chlorine it yields trichloromethylsulphurous chloride (the so-called sulphite of tetrachloride of carbon, $CCl^3.SO^2Cl = SO^2.CCl^4$) (Kolbe).—11. *Bromine* and sulphide of carbon do not act upon each other when passed through a red-hot tube.—12. The *fixed caustic alkalis* gradually dissolve disulphide of carbon, forming a brown solution, which is a mixture of carbonate and sulphocarbonate of the alkali-metal (Zeise):

$$3CS^2 + 3K^2O = K^2CO^3 + 2K^2CS^3.$$

13. With *alcoholic potash* it yields carbonate and ethyl-oxysulphocarbonate (xanthate) of potassium, which forms a yellow precipitate with copper-salts (Zeise):



$$CS^2 + C^2H^5.K.O = \left.\begin{matrix}(CO)''\\C^2H^5.K\end{matrix}\right\}S^2.$$

An aqueous or alcoholic solution of caustic potash, boiled with disulphide of carbon, forms with lead-salts a black precipitate of sulphide of lead, which affords a very delicate test for sulphide of carbon. It is instantly produced on dropping a dilute solution of that compound into a boiling solution of nitrate of lead containing potash, a distinct coloration being obtained, even with a liquid containing only a drop of sulphide of carbon in a quart of water.—14. With *aqueous ammonia*, it forms sulphocarbonate and sulphocyanate of ammonium, without any carbonate (Zeise):

$$2CS^2 + 4NH^3 = (NH^4)^2CS^3 + NH^4.CNS.$$

15. With a saturated solution of *ammonia-gas in anhydrous alcohol*, it yields the same products, together with sulphocarbamate of ammonium, produced by the simple union of ammonia with the disulphide (Zeise):

$$CS^2 + 2NH^3 = (NH^2\overset{\prime\prime}{CS}).NH^4.S.$$

16. With *triethylphosphine* it unites directly, forming a compound $P(C^2H^5)^3.CS^2$, which crystallises in splendid ruby-coloured prisms. The reaction affords an extremely delicate test for the presence of either of the constituent substances, and is especially applicable to the detection of sulphide of carbon in coal-gas. When a stream of the gas, purified from sulphuretted hydrogen in the usual manner, is passed through a solution of triethylphosphine in ether, contained in a bulb apparatus, a red colour soon appears in the liquid, and when sufficient gas has been passed through the liquid to evaporate the ether, the bulb-apparatus is seen to be lined with a network of the red crystals. (A. W. Hofmann. Ann. Ch. Pharm. cxv. 296.)

The sulphocarbonates M^2CS^3, or $M^2S.CS^2$, bear to disulphide of carbon the same relation that the carbonates M^2CO^3 bear to carbonic anhydride. Moreover by treating sulphocarbonate of ammonium with dilute sulphuric or hydrochloric acid, an oily, very acid liquid is precipitated, consisting of sulphocarbonic acid, H^2CS^3.

PROTOSULPHIDE OF CARBON. CS.—As already observed, it is doubtful whether this compound, the analogue of carbonic oxide, has yet been obtained, though there can be no doubt as to the possibility of its existence. Baudrimont (Compt. rend. xliv. 1000), states that it is obtained tolerably pure by passing the vapour of the disulphide over red-hot spongy platinum or pumice, and washing the resulting gas with solutions of acetate of lead and cuprous chloride, to free it from sulphydric acid and carbonic oxide, resulting from the action of air and moisture remaining in the materials. The gas thus obtained is described as colourless, smelling somewhat like the disulphide, not liquefiable at the temperature of a mixture of ice and salt; soluble in its own bulk of water; decomposed by lime-water into sulphide of calcium, and a volume of carbonic oxide equal to its own: $Ca^2O + CS = Ca^2S + CO$; and yielding when exploded with oxygen, equal volumes of CO^2 and SO^2.

Baudrimont likewise obtained the protosulphide, but mixed with sulphydric acid and carbonic oxide, by passing the vapour of the disulphide over red-hot charcoal; by the action of sulphydric acid on carbonic oxide at a red heat ($CO + H^2S = H^2O + CS$), and by several other processes.

Playfair (Chem. Soc. Qu. J. xiii. 248) endeavoured to prepare the protosulphide by passing the vapour of the disulphide over red-hot pumice, but obtained nothing but a mixture of carbonic anhydride, carbonic oxide, sulphydric acid, and nitrogen, saturated with vapour of disulphide of carbon; he observed no deposition of sulphur in the red-hot tube, though Baudrimont states that it choked up the exit-tube of his apparatus. Playfair attributes the formation of these gases to air and moisture retained by the pumice, though it had been previously ignited, or introduced into the tube together with the disulphide. He is of opinion that Baudrimont's gas, which yielded by explosion with oxygen, equal volumes of SO^2 and CO^2, was a mixture of equal volumes of CO and vapour of CS^2, which at common temperatures, and under the diminished pressure existing in the eudiometer, would have sufficient tension to diffuse itself in vapour through the carbonic oxide.

In face of these contradictory results, the question as to the actual formation of protosulphide of carbon must for the present be considered as undecided.

CARBON, SULPHOCHLORIDE OF. $CSCl^2$.—This compound, the analogue of phosgene, was discovered by Kolbe (Ann. Ch. Pharm. xlv. 53), and is produced: 1. By the action of dry chlorine on disulphide of carbon at ordinary temperatures, chloride of sulphur being formed at the same time: $CS^2 + Cl^4 = SCl^2 + CSCl^2$. A few grammes of the disulphide are left exposed for a few days to the action of perfectly dry chlorine in a closed flask, either in the dark or in sunshine; the resulting liquid is digested with water to decompose the chloride of sulphur, and the remaining oily liquid is freed from the acid products thereby formed, by repeated distillation with water and a small quantity of magnesia. It is essential to the production of this compound, that the materials be perfectly dry, as if moisture is present, another compound, trichloro-methyl-sulphurous acid is obtained (p. 776). At a red heat, a different action takes place, and tetrachloride of carbon is produced.—2. By passing a mi of sulphydric acid and vapour of tetrachloride of carbon through a tube kept moderate red heat: $CCl^4 + H^2S = 2HCl + CSCl^2$.

Sulphochloride of carbon is a yellow liquid, not miscible with water, havi peculiar and powerful odour, very irritating to the eyes. Specific gravity Boiling point 70° C. These numbers probably require correction, as it is very dif to obtain the compound free from sulphide of carbon. It is not decomposed by w or acids, not even by fuming nitric acid. Caustic potash decomposes it slowly, f ing carbonate and sulphide of potassium, and tetrachloride of carbon:

$$2CSCl^2 + 3K^2O = K^2CO^3 + 2K^2S + CCl^4.$$

CARBONATES. The carbonates form a numerous and important class of many of which occur as natural minerals. They are usually divided into *normal*, and *acid* carbonates, the normal or neutral salts having the composition

$$M^2CO^3 = M^2O.CO^2 = \left.\begin{matrix}(CO)''\\M^2\end{matrix}\right\}O^3.$$

The basic carbonates, however, all contain water, and by regarding the whole or of this water (or hydrogen) as basic, the carbonates, like the borates, phosphates silicates, may be divided into ortho-carbonates, $M^4CO^4 = \left.\begin{matrix}\overset{''''}{C}\\M^4\end{matrix}\right\}O^4$, and meta bonates, M^2CO^3,—or more generally orthocarbonates $= M^xH^{4n-x}C^nO^{4n}$, and met bonates $= M^xH^{2n-x}C^nO^{3n}$, the latter including the salts usually regarded as n carbonates. Nearly all the precipitates obtained by adding a solution of an alk carbonate to a salt of a heavy metal, contain water, and may be represented by o other of these formulæ. It is difficult to say whether the ortho- or the meta-carbo are the more numerous; but the carbonates of the stronger bases, viz. the alkali-m and alkaline-earth metals, are certainly meta-carbonates. Only a few acid carbo are known as definite salts, viz. those of potassium, sodium, and ammonium, and are metacarbonates containing hydrogen, *e. g.* monopotassic metacarbonate, or carbonate of potassium, $(KH)CO^3$.

Carbonates are formed by the action of carbonic acid, or the joint action of wate carbonic anhydride, on metallic oxides or hydrates, not in any case by the un carbonic anhydride with an oxide without the intervention of water. Lime-wat milk of lime, absorbs carbonic anhydride rapidly, forming carbonate of calcium perfectly dry carbonic anhydride may be passed over anhydrous lime withou sorption. Even dry hydrate of potassium, KHO, absorbs carbonic anhydride slowly, and soon becomes covered with a crust of acid carbonate of potassium (KH $CO^2 = KHCO^3$), which protects the rest from alteration; but the moist hydra the aqueous solution, absorbs it with the greatest avidity; similarly with other The carbonates of the earth-metals proper and heavy metals are most easily obt by precipitating a soluble salt of the metal with an alkaline carbonate; but the cipitate, as already observed, almost always contains water, and very rarely ha composition of an anhydrous metacarbonate M^2CO^3. The sesquioxides, alu ferric oxide, chromic oxide, uranic oxide, &c., do not absorb carbonic anhydride when moist, and their solutions, when mixed with alkaline carbonates, yield precipi not of carbonates, but of hydrates. Metals like zinc and iron, which readily r hydrogen in acid solutions, may be converted into carbonates by simply imme them in water containing carbonic acid.

Carbonates are also formed in the decomposition by heat of organic salts c stronger bases, viz. of the alkali-metals and of the alkaline-earth metals. Oxalat resolved into carbonates and carbonic oxide, without separation of carbon:

$$C^2M^2O^4 = CM^2O^3 + CO$$

formates into carbonates, with evolution of carbonic oxide and hydrogen, and separation of carbon:

$$2CHMO^4 = CM^2O^3 + CO + H^2.$$

The salts of most other organic acids yield a considerable quantity of free c besides combustible gases; acetates and the salts of other fatty acids, and a few o are resolved by dry distillation into carbonates and acetones (pp. 31, 32).

The carbonates of ammonium, potassium, and sodium are easily soluble in w carbonate of lithium dissolves in about 100 pts. of water; the carbonates of all metals are insoluble, or nearly so, in water; but all are slightly soluble in containing free carbonic acid. Acid carbonates are doubtless formed in this but none of these, excepting the acid carbonates of the alkali-metals, can b tained in the solid state, as the solutions, when boiled or evaporated, give off bonic anhydride and deposit neutral carbonate. All metallic carbonates, exce carbonate of ammonium, are insoluble in alcohol. Carbonates of organic alkalis are for the most part soluble in water and in alcohol; carbonates of alcohol-radicles, insoluble in water, soluble in alcohol.

Most carbonates are easily decomposed by heat. The carbonates of the heavy metals are all decomposed at a low red heat, giving off carbonic anhydride, and leaving a residue of metal or of oxide. The carbonates of the earth-metals proper, and of calcium and strontium, require a stronger red heat to decompose them; carbonate of barium is decomposed only at a white heat; and the carbonates of the alkali-metals, when dry, resist the action of the strongest heat, excepting when a current of dry air or other gas is passed over them; in that case carbonate of sodium gives up a small quantity of carbonic anhydride, and carbonate of lithium a considerable quantity. (H. Rose.)

Nearly all carbonates are more or less decomposed by water, with the aid of heat, those of the weaker bases even at ordinary temperatures, so that precipitated carbonates are very apt to undergo partial decomposition during washing. Even the carbonates of barium, potassium, sodium, and magnesium are converted into hydrates when heated to redness in a stream of aqueous vapour; partially also in a stream of moist air or hydrogen gas: the carbonates of barium and potassium do not suffer any decomposition in a current of dry air or hydrogen. (H. Rose, Pogg. Ann. lxxxv. 99, 279; Jahresber. f. Chem. 1852, p. 309.)

Carbonates are decomposed, with evolution of carbonic anhydride, by nearly all acids, even at ordinary temperatures, and at a red heat by many acids whose salts are themselves decomposed at ordinary temperatures by carbonic acid, *e.g.* by boric, silicic, and several metallic acids. The effervescence which accompanies the decomposition affords a ready indication of the presence of a carbonate. Any of the stronger acids may be used to effect the decomposition, but, generally speaking, hydrochloric or nitric acid is preferable to sulphuric acid, because the latter often forms insoluble or sparingly soluble salts, the presence of which interferes with the reaction. If the carbonate is in solution, the liquid should be concentrated before adding the acid, as in a very dilute liquid the carbonic acid may remain dissolved instead of escaping as gas. The decomposing acid must also be added in excess, otherwise an acid carbonate of the alkali-metal will be formed, and no effervescence will be observed. If the substance to be examined is a mineral, it must be finely pulverised, and the powder should be soaked in water before adding the acid; otherwise the escape of air-bubbles might be mistaken for an evolution of carbonic anhydride. Many other volatile acids produce effervescence when eliminated from these compounds, *e.g.* hydrochloric, hydriodic, sulphurous, sulphydric acid, &c.; but they may all be distinguished from carbonic acid by their colour or their odour, also by passing the evolved gas into lime-water or baryta-water, and proceeding as described at page 768.

CARBONATE OF ALUMINIUM (?) It is doubtful whether such a compound exists. Saussure stated long ago that alkaline carbonates throw down from solutions of aluminium, a compound of hydrate of aluminium with a small quantity of the alkaline carbonate, and that the hydrate is partially soluble in aqueous carbonic acid, but is completely separated on warming the solution or exposing it to the air (Gm. iii. 309). Other chemists have, however, obtained different results. According to Muspratt (Chem. Soc. Qu. J. ii. 206), the precipitate formed by alkaline carbonates consists of $3Al^2O^3.2CO^2 + 16H^2O$. Langlois (Ann. Ch. Phys. [3] xlviii. 502) found $8Al^2O^3.3CO^2 + 40H^2O$; and Wallace (Chem. Gaz. 1858, 410) gives, as the composition of the precipitate, $3Al^2O^3.2CO^2 + 9H^2O$. H. Rose, on the contrary (Pogg. Ann. xli. 462), states that the precipitate formed by carbonate of ammonium is a compound of trihydrate of aluminium with carbonate of ammonium. $Al'''H^3O^3 + NH^4.H.CO^3$, the ammonia-salt not being removable by washing. From experiments recently made in Dr. Muspratt's laboratory by Mr. James Barratt (Chem. News, i. 110), it appears that the precipitate formed by carbonate of sodium in a solution of chloride of aluminium, after being washed and dried, then triturated with water, again washed, and dried over sulphuric acid, consists of pure hydrate of aluminium.

CARBONATE OF ALLYL. See CARBONIC ETHERS.

CARBONATES OF AMMONIUM. These salts have already been described (p. 190). They are all metacarbonates, and may be formulated as follows:

Neutral carbonate, $(NH^4)^2O.CO^2 = \left.\begin{matrix}\overset{\prime\prime}{C}O\\(NH^4)^2\end{matrix}\right\}O^2$

Acid carbonate, $\left.\begin{matrix}NH^4\\H\end{matrix}\right\}O.CO^2 = \left.\begin{matrix}\overset{\prime\prime}{C}O\\NH^4.H\end{matrix}\right\}O^2$

Sesquicarbonate, $2(NH^4)^2O.3CO^2 + 3aq. = \left.\begin{matrix}(\overset{\prime\prime}{C}O)^3\\(NH^4)^4.H^2\end{matrix}\right\}O^6 + 2aq.$

Carbonate of Amyl. See Carbonic Ethers.

Carbonate of Barium. $Ba''CO^3$ = $Ba''O.CO^2$.—This salt occurs abu
in nature as *Witherite*, a mineral which frequently accompanies lead-ores.
tallises in the trimetric system, isomorphously with arragonite, the crystals
frequently prismatic, from predominance of the faces ∞P, $\infty \breve{P} \infty$, and $\breve{P} \infty$. T
bination $P . 2\breve{P}\infty . \infty\breve{P}\infty . \infty P$, is also common, forming a six-sided pris
pyramidal summits. Ratio of axes, $a : b : c = 0{\cdot}5950 : 1 : 0{\cdot}7413$. Inclina
faces: $\infty P : \infty P = 61° 30'$; $\breve{P}\infty : \breve{P}\infty = 71° 47'$; $2\breve{P}\infty : 2P\infty = 110° 42'$. C
imperfect parallel to $\infty\breve{P}\infty$, ∞P, and $\breve{P}\infty$ (Kopp). It occurs also in globular, t
and botryoïdal forms; structure either columnar or granular; also amorphous.
gravity = 4·29 to 4·35. Hardness = 3 to 3·75. Lustre vitreous, inclining to
on fractured surfaces. Colour white, or often yellowish or greyish. Streak
Subtransparent to translucent. Fracture uneven. Brittle. Witherite is fo
Alston Moor in Cumberland, and in splendid crystals at Fallowfield in North
land. It occurs also in many places on the continent of Europe, in the Alt
Coquimbo, Chili, &c. It is sometimes found altered to heavy spar by the a
soluble sulphates.

Carbonate of barium is rapidly formed when baryta, either in the anhydrou
or in crystals, or in solution, is exposed to the air, and is easily prepared by
tating an aqueous solution of the chloride or nitrate with carbonate of ammon
a solution of the sulphide with carbonate of sodium; the salt obtained by t
method is liable to be contaminated with a sulphur-compound. It may also
pared in an impure state by igniting in a crucible a mixture of 10 pts. of
sulphate of barium, 2 pts. of charcoal, and 5 pts. of carbonate of potassium (pe
A mixture of sulphide of potassium and carbonate of barium is then obtaine
which the sulphide of potassium may be extracted by water. The impure ca
thus produced may be used for the preparation of other barium-salts, but the sa
obtained will contain iron.

Carbonate of barium artificially prepared is a soft white powder. It is po
and is used as rat-bane. It is very slightly soluble in water, about 1 pt. i
rather more (in 588 pts. according to Lassaigne) in water saturated with carbon
It dissolves easily, even in the cold, in chloride, nitrate, and succinate of amm
and when boiled with chloride of ammonium, it is completely decomposed, y
carbonate of ammonium and chloride of barium. When shaken up with aque
phate of potassium or sodium, it yields sulphate of barium and carbonate of the
metal. It bears a strong red heat without decomposition; but at the heat of
fire it gives off carbonic anhydride and leaves baryta. The decomposition is
facilitated by the addition of charcoal. Carbonate of barium is decomposed by
of water at a red heat, and very easily if mixed with an equal weight of c
slaked lime.

An *acid carbonate*, $2Ba''O.3CO^2$, or $2Ba''CO^3.CO^2$, was said by Boussingau
Ch. Phys. [2] xxix. 280) to be obtained by precipitating chloride of barium w
quicarbonate of sodium. H. Rose, on the other hand, by mixing chloride of
with diacid carbonate of sodium or potassium, obtained nothing but neutral ca
of barium, and is of opinion that acid carbonates of barium cannot exist exce
solution.

Carbonate of Bismuth.—When nitrate of bismuth is dropt into a sol
alkaline carbonate, a white precipitate is formed, consisting of $Bi^2O^3.CO^2$ (Ber
The precipitate formed with alkaline carbonates contains $Bi^2O^3.CO^2 + \frac{1}{2}aq.$, t
escaping at 100° C. (Lefort.)

Carbonate of Cadmium, $Cd''CO^3$, occurs in small quantity, associate
native carbonate of zinc. Cadmium-salts yield with carbonate of ammonium,
precipitate, containing $Cd''CO^3 + aq.$, which gives off its water between 80° and
at a higher temperature, carbonic anhydride goes off, and brown oxide of cad
left, which when exposed to the air is gradually reconverted into carbonate (
J. Pharm. [3] xii. 406). According to H. Rose (Pogg. Ann. lxxxv. 304), th
pitates formed by alkaline carbonates in solutions of cadmium. contain very littl
and approach very nearly to the formula $Cd''CO^3$. Moist hydrate of cadmium
carbonic acid from the air, and at 300° gives off all its water, and is convert
$2Cd''O.Cd''CO^3$, or $Cd''O.Cd^2CO^4$.

Carbonates of Calcium.—The *metacarbonate*, $Ca''CO^3 = Ca''O.CO^2$, occu
abundantly in all parts of the world, in the forms of calcspar, marble, limestone of
kinds, and chalk; also in egg-shells and the shells of molluscs, and, together wi
phate of calcium, in bones. It is formed when lime, either anhydrous or hyd
exposed to the air in its ordinary state of moisture, but not by the action of c
anhydride on anhydrous lime. It may be obtained pure by dissolving calcine

r marble, in hydrochloric acid, adding ammonia or milk of lime to pre-
a, oxide of iron, and earthy phosphates, then filtering, precipitating the
h carbonate of ammonium, washing thoroughly, and drying at a heat
s.

calcium is dimorphous, crystallising in the hexagonal system as calcspar
n the trimetric system as arragonite (p. 358). The specific gravity of
es from 2·6987 to 2·75; of the latter, generally from 2·92 to 3·28. The
pared salt is a white powder, consisting of small crystals, which usually
of arragonite when precipitated from hot solutions, and of calcspar when
om cold solutions, especially if dilute. The microscopic crystals of arra-
ly change into rhombohedrons of calcspar if left for some time under the
359). The precipitate formed in hot solutions, assumes the crystalline
ce; that from cold solutions is amorphous at first, and gradually becomes

f calcium is tasteless, and has a slight alkaline reaction to test-paper.
ringly soluble in water, requiring, according to Fresenius (Ann. Ch.
7), 88·34 pts. of boiling, and 10,601 pts. of cold water to dissolve it; the
ghtly alkaline. Water containing free carbonic acid dissolves it much
When recently precipitated, it dissolves easily in aqueous carbonate, sul-
lorate, nitrate, or succinate of ammonium: but when it has assumed the
n by long standing, it dissolves but sparingly, forming a turbid liquid.
ions sometimes become turbid on standing, but do not deposit the whole
which they contain. Hence calcium can never be completely precipi-
nate from solutions containing ammoniacal salts. Carbonate of calcium
lution of sal-ammoniac, the water being renewed as it evaporates, dis-
completely as chloride of calcium, with evolution of carbonate of am-

f calcium heated to full redness in open vessels, is resolved into lime and
ride. The decomposition commences even at a low red heat, so that in
cium as carbonate in analysis, the ignited precipitate should, before
noistened with carbonate of ammonium, and again heated, just sufficiently
e excess of that salt; by this means, any carbonic acid that may have
f will be restored. In a current of air or any other gas, and especially of
omposition takes place at a lower temperature. If, on the other hand,
of calcium be ignited a closed iron tube, so that the carbonic anhydride
it fuses to a fine-grained mass, consisting of crystals of calcspar, and
earance of marble.

eutral Carbonate of Calcium, Hydrocalcite, $Ca''CO^3.5aq$.—This salt is
all, very acute, rhombohedral crystals, of specific gravity 1·783, by boil-
concentrated solution of sugar, milk-sugar, starch, or gum, and leaving
some months in a cold place (Pelouze, Ann. Ch. Phys. [2] xlviii. 301).
exposing a solution of lime in sugar-water, to the action of a 12-pair
, obtained crystals having the same composition, but the form of a
with dihedral summits, like arragonite. Crystals of the same form and
ere found by Scheerer (Pogg. Ann. lviii. 382), in a running stream.
r found six-sided prisms of the same composition, deposited from spring-
opper tube of a pump.

remain unaltered below 19° or 20° C., either in the air or under
nble to a white powder at a somewhat higher temperature, and if quickly
they are converted into a pasty mass, which dries up to a powder. In
hey crumble to a white powder; also in hydrated alcohol: but boiling
l extracts from them only 2 at. water, rendering them opaque, but with-
form. The remaining crystals with 3 at. water, effloresce very quickly
may be kept unaltered at a temperature below 10°. (Gm. iii. 188.)

ate, Ca^2CO^4, or $2Ca''O.CO^2$.—This, with 1 at. water (sometimes regarded
onate, $Ca^2CO^3.2CaHO$), is, according to Fuchs (Pogg. Ann. xxvii. 601),
n of the slaked lime produced by exposing quick lime to the air in its
At a strong red heat, it gives off water and carbonic anhydride, and
lime which slakes in water, not with violence, but slowly and with only
of temperature. At a low red heat, the hydrated orthocarbonate gives off
ving the anhydrous salt, Ca^4CO^4, which, according to Fuchs, is likewise
ordinary carbonate of calcium is exposed to a moderate red heat, only
rbonic anhydride being then expelled, and leaving a residue, which in
ater does not slake but hardens, being in fact converted into the hydrated
.

ate.—This salt, which perhaps has the composition $Ca''H^2(CO^3)^2$, is known
n, and may be obtained in that state by passing carbonic anhydride into

cold water in which the neutral carbonate is suspended. Water saturated w
bonic acid dissolves $\frac{1}{1428}$ part of the neutral carbonate, at 0° C., and $\frac{1}{113}$
(Lassaigne, J. Chim. méd. 1848, p. 312). In consequence of this sparing so
solutions of calcium-salts are precipitated by alkaline bicarbonates even in t
The solution of the acid salt has a slight alkaline reaction if quite saturated, bu
carbonic acid is in excess, it exhibits an acid reaction. It is decomposed, wi
ration of the neutral carbonate, on exposure to the air, or more quickly when
It plays an important part in the economy of nature, being formed wherever ca
of calcium or other calcareous formations, especially silicates, come in cont
water containing carbonic acid, and thus entering in greater or smaller quan
the composition of almost all natural waters. Waters which contain it in cons
quantity, form deposits of carbonate of calcium on their banks or on objects in
in them: hence the formation of calcareous petrifactions, of calcareous t
sinter, of stalactites, stalagmites, &c. To the same cause also is due the t
which appears in river or spring water when heated, and the incrustation or fu
kettles and boilers. The formation of this incrustation may to a certain e
prevented, by the addition of sal-ammoniac to the water, whereby, as already o
the carbonate of calcium is converted into soluble chloride.

CARBONATE OF CERIUM, $Ce''CO^3 + 3aq.$, or $Ce''H^2CO^4 + 2aq.$, formed,
posing hydrated cerous oxide to the air, or by precipitation, is a white powde
when ignited the air, is partly converted into lemon yellow coroso-ceric ox
occurs native, with fluoride of calcium, as *Parisite* (*q. v.*)

CHROMOUS CARBONATE, is obtained by adding a solution of protochl
chromium to carbonate of potassium. The precipitate is red or reddish-brow
solution is hot, but has the form of dense yellow or bluish-green flakes, if the so
cold: it appears, however, to have the same composition in all cases. (Mober

CARBONATES OF COBALT. The anhydrous carbonate $Co''CO^3$, is obta
heating chloride of cobalt with carbonate of calcium to 150° C. in a sealed
eighteen hours, or by decomposing the chloride with a solution of acid carb
sodium supersaturated with carbonic acid, and heated to 140° in a strong vess
with a cork, through which the carbonic acid escapes slowly. It is a ligh
coloured, sandy powder, composed of microscopic rhombohedrons, and is not atta
the cold by acids, not even by nitric or hydrochloric acid. (Sénarmont, A
Phys. [3] xxx. 129.)

The precipitates formed by adding cobalt-solutions to alkaline carbonate
hydrated carbonates, or double carbonates of cobalt and the alkali-metal. Th
may be represented as ortho- or meta-carbonates, combined in various proporti
hydrate of cobalt, the composition varying according to the temperature and
tration of the solutions.

The precipitate formed on adding sulphate of cobalt to neutral carbonate of
the solutions being concentrated or moderately dilute, and either hot or cold
coloured, and when dried at 100° C. consists of $2Co''CO^3.3Co''H^2O^2 + aq.$ or
$Co''H^2O^2 + 3 aq.$ (Setterberg, Pogg. Ann. xix. 55; Winkelblech, Ann. Ch
xiii. 148; H. Rose, *ibid.* lxxx. 237). But very weak solutions mixed at th
heat, yield a blue precipitate, consisting of $Co''CO^3.2Co''H^2O^2 + aq.$ or Co^3CO
$+ 2 aq.$ The precipitates are very difficult to wash. Heated above 150° C. i
with the air, they gradually give off water and carbonic anhydride, and are c
into sesquioxide of cobalt (H. Rose). The first-mentioned precipitate is partly c
into sesquioxide by boiling with water (Field, Chem. Soc. Qu. J. xiv. 5
same precipitate digested with solution of diacid carbonate of sodium or of am
is gradually converted into $3Co''CO^3 + aq.$ (H. Deville, Ann. Ch. P
xxxiii. 75.)

A hydrated carbonate of cobalt called *Remingtonite*, whose precise comp
not known, occurs as a soft, earthy, rose-coloured incrustation, on thin veins o
tine, at a copper-mine near Finksburg, Carroll County, Maryland. (J. C. Bo
Am. J. [2] xv. 48.)

Carbonate of Cobalt and Potassium.—Nitrate or sulphate of cobalt forms wi
of diacid carbonate of potassium a rose-coloured precipitate, which gradually
to a network of rose-coloured crystals, easily decomposed by water, and consi
meta-carbonate. $(Co''KH)C^2O^6 + 4aq.$, [or $2(Co''O.CO^2) + K^2O.2CO^2$
(H. Rose, H. Deville). Nitrate of cobalt and sesquicarbonate of potassi
distinct crystals, containing $Co''K^2(CO^3)^2 + 4aq.$ (Deville.)

Carbonate of Cobalt and Sodium.—Nitrate of cobalt and sesquicarbonate
yield a mixture of small prismatic crystals, $Co''Na^2(CO^3)^2 + 4 aq.$, and dark-re
apparently cube-like rhombohedrons, containing $Co''Na^2(CO^3)^2 + 10aq.$ (De

ES OF COPPER.—Two of these compounds occur as natural minerals,
and *Azurite.* They may be most simply represented as orthocarbonates,

***Malachite* as *dicupric orthocarbonate*,** $\overset{''}{\mathrm{Cu}}{}^2\mathrm{CO}^4 + \mathrm{aq}.$

***Azurite* as *tricupric orthocarbonate*,** $\left.\begin{matrix}\overset{''}{\mathrm{Cu}}{}^3\\ \mathrm{H}^2\end{matrix}\right\}\mathrm{C}^2\mathrm{O}^8.$

be regarded as metacarbonates combined with cupric hydrate, viz.
$\mathrm{Cu''CO^3.Cu''H^2O^2}$; azurite as $\mathrm{2Cu''CO^3.Cu''H^2O^2}$. The hydrated di-
formed artificially by precipitation. The anhydrous metacarbonate,
known.

Orthocarbonate*,** $\overset{''}{\mathrm{Cu}}{}^2\mathrm{CO}^4 + \mathrm{aq}.$ ***Malachite*, *Green Carbonate of
***ain green*, *Atlas ore*.**—This mineral forms prismatic crystals belonging to
system, in which the lengths of the orthodiagonal, clinodiagonal, and prin-
one another as 1·273 : 1 : 0·5358. The inclination of the clinodiagonal
axis does not differ much from 90°. The crystals are generally reduced
by predominance of the faces ∞P and ∞P∞, and terminated by oP, +P,
age perfect parallel to −P∞ and ∞P (Kopp). More frequently, how-
in laminar, fibrous, compact, or earthy masses. Specific gravity = 3·7
ness = 3·5 to 4. It varies in colour from emerald to grass-green, and
grees of transparency down to perfect opacity. It takes a high polish,
rge masses is cut into tables, snuff-boxes, vases, &c. Malachite usually
her ores of copper. Perfect crystals are very rare. The fibrous variety
tly in Siberia, at Chessy in France, at Sandlodge in Shetland; the com-
Schwartz in the Tyrol, in Cornwall, and in Cumberland. At the copper
ne Tagilsk, a bed of malachite was opened which yielded many tons of
Malachite is also found on the west coast of Africa, and in several
rth America. (Dana, ii. 458.)

treated with alkaline carbonates, yield at first a greenish-blue preci-
ng, according to Brunner, of $\mathrm{Cu^2CO^4 + 2aq.}$; which, however, when left
the liquid, and washed, becomes compact and green, and acquires the
malachite. When heated to 200° C. it is slowly converted into black
which obstinately retains a small quantity of water. Malachite slowly
the same manner at 220°. The dicupric salt, either native or preci-
mposed by boiling with water, giving up carbonic acid, and being entirely
black oxide of copper. (H. Rose; F. Field, Chem. Soc. Qu. J. xiv. 71.)
with neutral carbonate of sodium at 120° F. (48·8° C.) it is converted
^{3}, or $\mathrm{Cu^2CO^4.4CuO}$. Boiled with sesquicarbonate of sodium, it dissolves,
liquid, which is not decomposed even by long boiling; but when sulphate
iled for a very long time with sesquicarbonate of sodium, a green precipi-
c carbonate is obtained, and on filtering from this and adding more sul-
r to the filtrate, the basic salt just mentioned is precipitated, as a dense
(Field). According to Deville, dicupric carbonate digested with
ate of sodium is partly converted into $\mathrm{8Cu''O.CO^2 + 5H^2O}$.

dicupric carbonate, $\mathrm{Cu^2CO^4}$, or $\mathrm{2Cu''O.CO^2}$, occurs, according to
ineralogy, i. 601), as *mysorin*, a mineral from Mysore in Hindostan,
ferric oxide and silica. Dana suggests that it may be only an impure

***Orthocarbonate*,** $\overset{''}{\mathrm{Cu}}{}^3\mathrm{H^2C^2O^8}$ (or $\mathrm{3Cu''O.2CO^2 + H^2O}$). ***Azurite*,**
Carbonate of Copper*, *Blue Malachite*, *Chessy Copper*, *Chessylite*, *Kupfer-
ineral occurs in fine crystals, belonging to the monoclinic system, in
hodiagonal, clinodiagonal, and principal axis are to one another as
76. Inclination of axes 87° 39′. Observed faces ∞P . oP. [P∞] .
, together with others of less frequent occurrence. The crystals are
ally elongated in the direction of the orthodiagonal. Cleavage parallel
p's *Krystallographie*, p. 303). The mineral occurs also massive and in
es, having a columnar composition, also dull and earthy. Specific gravity
1. Hardness = 3·5 to 4·25. Lustre vitreous, almost adamantine.
shades of azure, passing into Prussian-blue. Streak blue, lighter than
nsparent to sub-translucent. Fracture conchoïdal. Brittle. It is found
stallisations at Chessy near Lyons, in fine crystals also in Siberia, at
e Bannat, at Wheal Buller, near Redruth in Cornwall; at Porto Bello,
; and in small quantities at Alston Moor, Wanlockhead, &c. It is
he States of Pennsylvania, New York, and New Jersey. (Dana, ii. 459.)
ground to fine powder forms a bright blue pigment; but it is not of
t is apt to turn green by exposure. When boiled with water, it decom-

poses like malachite, yielding black oxide of copper. Heated with a concentra
lution of diacid carbonate of sodium, it yields a blue solution, which, after pro
boiling, deposits a green precipitate of malachite (Field). According to Pl
(Ann. Ch. Phys. [2] vii. 44) a cupric carbonate, called *blue verditer*, having th
composition as azurite, is obtained by a secret process.

Potassio-cupric Carbonate.—Nitrate of copper forms with diacid carbonate o
sium, a deep blue liquid, which after a few hours deposits a silky mass, consi
$5Cu''O.K^2O.5CO^2 + 10$ aq. or $(Cu^5K^2H^6)C^5O^{20} + 6$ aq. (Deville, Ann. Ch
[3] xxxiii. 75.)

Sodio-cupric Carbonate, $Cu''Na^2(CO^3)^2 + 6$ aq., is obtained by adding an acid s
of nitrate of copper to carbonate of potassium containing soda, and leaving the pre
in the liquid for a considerable time; also by the action of diacid carbonate of
on dicupric carbonate at 40°—50° C. It forms rhombic prisms, having the a
the obtuse edges = 123° 14′, and acuminated with four faces resting on the p
edges. (Deville.)

Cuprous Carbonate?—The yellow precipitate obtained by adding carbonate of
to a solution of cuprous chloride in hydrochloric acid was said by Colin to be a
carbonate, but according to L. Gmelin (*Handbook*, v. 414), it is merely
hydrate.

Carbonate of Cuprammonium, $(N^2H^6Cu'')''CO^3$, is obtained in large deep blue
by dissolving tricupric or dicupric carbonate in carbonate of ammonia, and
the solution into alcohol. It is rapidly decomposed by water into carbonate
monia and a basic carbonate of copper, $Cu^2CO^4.Cu''H^2O^2 + 2$ aq. (Favre, *T*
Chimie par Pelouze et Frémy, iii. 201.) The same ammoniacal compound app
be formed when cupric oxide or finely divided metallic copper is digested in a
with access of air.

Carbonate of Didymium is obtained as a white, slightly rose-coloured
tate containing $Di''CO^3 + 2$aq., on adding an alkaline carbonate to the soluti
didymium-salt. At 100° C. it gives off two-thirds of its water and a small q
of carbonic acid. (Marignac.)

Carbonate of Ethyl. See Carbonic Ethers.

Carbonate of Glucinum is produced when the hydrate is exposed to
also by precipitating glucinum-salts with alkaline carbonates, not in excess,
boiling a solution of carbonate of glucinum and ammonium. It appears to vary
position; the precipitate obtained by the last-mentioned process has, accor
Schaffgotsch, the composition $5Gl''O.CO^2 + 5$aq. or $Gl^2CO^4.3Gl''H^2O^2 + 2$aq. It
to be decomposed by boiling with water. It dissolves in alkaline carbonates,
double salts.

Carbonate of Glucinum and Ammonium.—When a solution of glucina in aque
bonate of ammonia is heated to the boiling point, till the liquid begins to show tu
then filtered, and the filtrate mixed with alcohol till it becomes milky, white
parent crystals are gradually deposited, containing $4Gl''O.3CO^2.H^2O + 3[(NH^4)$
or perhaps $Gl''H^2O^2.3Gl''(NH^4)^2(CO^3)^2$. They become dull on exposure to the air,
luble in absolute alcohol, but dissolve readily in cold water, and are decomp
hot water, with evolution of carbonate of ammonia. (Debray, Ann. Ch. Pl
xliv. 5.)

Carbonate of Glucinum and Potassium, $Gl''H^2O^2.3Gl''K^2(CO^3)^2$, is obtained
same manner as the ammonium-salt, which it resembles in its properties. (De
Carbonate of glucinum likewise forms a double salt with carbonate of sodiu

Carbonates of Iron.—*Ferric carbonate* does not appear to exist. The pre
formed by alkaline carbonates in solution of ferric nitrate, consists, accor
L. Gmelin (*Handbook*, v. 222), of ferric hydrate without a trace of carbo
According to Soubeiran (Ann. Ch. Phys. [2] xliv. 326), the precipitate thro
by alkaline carbonates from ferrous salts, contains, after thorough washing an
sure in thin layers to the moist air of a cellar for six months, 71·4 per cen
oxide (quite free from ferrous oxide), 8·3 carbonic anhydride, and 20·0 water;
is doubtful whether a definite carbonate is formed.

Double carbonates of ferricum and the alkali-metals appear to be capable of
in solution, though not in the solid state. When a ferric salt is precipitated
centrated carbonate of ammonia, the precipitated ferric hydrate gradually redis
but is slowly deposited again on diluting with water. Well washed ferric
however, does not dissolve in carbonate of ammonia, so that the presence of the
niacal salt formed in the decomposition appears to be necessary to the solution
ferric hydrate. Similar reactions are obtained with strong solutions of carbo
potassium or sodium.

Ferrous Carbonate.—The anhydrous metacarbonate $Fe''CO^3$ or $Fe''O.CO$
abundantly as a natural mineral, viz. *Spathic* or *Sparry iron ore*, also called

iderose, Brown spar, Sphærosiderite, Junkerite, Strahlstein, Eisenspath,
, Oligonspath. This mineral forms rhombohedral crystals, having fo:
orm a rhombohedron, in which the principal axis is to the secondary
: 1, and the inclination of the faces meeting in the terminal edges
s form being either solitary or predominant, and often with curved
es in twin-crystals. It also occurs in botryoïdal and globular forms (as
, occasionally in silky fibrous masses; often cleavable massive, with cleav-
ulate; also coarse or fine granular. Specific gravity = 3·7 to 3·9. Hard-
·5. Lustre vitreous to pearly. Streak white. Colour ash-grey, yellowish-
-grey; also brown and brownish-red, rarely green; sometimes white.
subtranslucent. Fracture uneven. Brittle. (Dana, ii. 445.)

carbonate would contain 37·93 per cent. carbonic anhydride and 62·07
The mineral always contains more or less of the carbonates of manga-
um, and calcium. A black variety from Babbowsky gave 36·61 CO^2,
51 MnO, trace of MgO, 0·59 CaO, and 0·60 gangue. A specimen
hbourhood of Durham yielded 35·90 CO^2, 54·57 FeO, 1·15 MnO, 3·18
water (= 97·43). The variety called oligonspar contains 25·31 per
us oxide; other varieties contain 12 to 15 per cent. magnesia.

onate is a very abundant mineral, occurring in gneiss, mica slate, clay
nnection with the coal formation. At Freiberg it occurs in silver mines.
accompanies tin. It is also found accompanying copper and iron py-
vitreous copper, &c. In New York, according to Beck, it is almost
ted with specular iron. Occasionally it is found in trap rocks as sphæ-
na). A siliceous or argillaceous variety called *clay iron stone*, which
coal measures, is one of the most abundant and valuable ores of iron.
ntities of it are found and worked in South Staffordshire, at Merthyr
h Wales, and near Glasgow.

errous carbonate may be prepared artificially by processes similar to those
bed for carbonate of cobalt (p. 782). It then forms a greyish-white crys-
omposed of minute rhombohedrons, scarcely attacked by dilute acids,
able in dry air, gradually assuming a light red tint in moist air. It is
rey colour and less alterable in the air in proportion as the heat em-
eparation has been greater and longer continued. (Sénarmont, Ann.
xxx. 129.)

rrous carbonate is precipitated on mixing a ferrous salt with an alkaline
hick white flakes, which, on exposure to the air, absorb oxygen and give
id, first assuming a dirty green colour, and ultimately changing to yel-
ferric hydrate. Hence it is difficult to obtain the precipitated ferrous
pure and definite state. The best mode of proceeding is to precipitate
te quite free from ferric sulphate, with alkaline monocarbonate or
oth salts being dissolved in water which has been thoroughly freed
iling, wash the precipitate out of contact with the air, *e.g.* by decan-
oroughly de-aërated water, keeping the vessel quite full and closed, and
mosphere of carbonic anhydride. The salt thus prepared is a greenish
r, which is used in medicine; it is tolerably permanent if thoroughly dried;
oxidises quickly in the air, becoming hot, and giving off water and car-
t may be rendered more permanent by mixing it with sugar while

-Aqueous carbonic acid dissolves ferrous carbonate; also metallic iron
of hydrogen. The solution, which exists in many natural waters, called
rs, is colourless, has a slightly ferruginous taste, is decomposed, with
rric hydrate, by contact with the air, and gives a black precipitate with
ydrogen. To preserve chalybeate water in vessels, they must first be
bonic anhydride, then opened and filled below the surface of the water,
ed under water. A less efficient mode of preservation is the introduc-
re and a few grains of sugar.

s OF LANTHANUM, $La^2CO^3 + 3$ aq., is found native as *Lanthanite*, a
rly mistaken for carbonate of cerium) occurring in four-sided plates or
of the trimetric system, with bevelled edges; also fine-granular, and
fic gravity 2·67 (?) Hardness 2·5 to 3. It has a dull or pearly lustre,
hite, faint pink, or yellowish colour. It is found coating cerite at
eden, and in silurian limestone, with the zinc ores of the Saucon valley,
, Pennsylvania. The American mineral was found by J. L. Smith to
per cent. LaO, with oxide of didymium, 22·58 CO^2, and 24·09 water
e formula requiring 52·94 LaO, 21·11 CO^2, and 25·95 water. With borax
salt it yields a glass having an amethystine colour, arising from didy-
a, ii. 456.)

Carbonate of lanthanum obtained by precipitation forms a white gelatinous
which gradually changes into shining crystalline scales.

CARBONATES OF LEAD.—The anhydrous metacarbonate, $Pb''CO^3$ or $Pb''O.$
found native as *white lead ore* or *cerusite*, in crystals of the trimetric system, i
phous with arragonite, witherite, and strontianite, and in which the brachydia
macrodiagonal, and principal axis are in the ratio of 0·6100 : 1 : 0·7236. Ordinar
bination $P \,.\, \infty P \,.\, \bar{P}\infty \,.\, 2\breve{P}\infty \,.\, \infty\breve{P}\infty$, with $2\breve{P}\infty$ predominant. Inclination o
$\infty P : \infty P = 62° 46'$; $\bar{P}\infty : \bar{P}\infty = 71° 47'$; $2\breve{P}\infty : 2\breve{P}\infty = 110° 42'$. Cl
moderately easy parallel to ∞P, less so parallel to $2\breve{P}\infty$. It is sometimes fo
twin-crystals, the face of combination being ∞P (Kopp's *Krystallographie*, p.
rarely fibrous; often granularly massive and compact. Specific gravity 6·465 to
Hardness 3 to 3·5, in some earthy varieties as low as 5·4. Colourless when pure
sparent or translucent in various degree and with adamantine lustre. Fracture co
dal. Very brittle. White lead ore is found in Cornwall and Cumberland, at Le
and Wanlockhead in Scotland, in Siberia, in the Harz, in Bohemia, and many
localities. It sometimes occurs altered to phosphate of lead by the action of
containing phosphate of calcium; to galena by the action of sulphuretted hyd
and to minium by oxidation; also more or less to magnesite, malachite, and c
colla. (Dana.)

Horn-lead or *cerasine* is a compound of carbonate and chloride of lead.

Hydrocarbonates.—The precipitate formed in solutions of lead-salts by a
carbonates varies in composition according to the temperature and concentration
liquids. According to Berzelius, the anhydrous metacarbonate is obtained by t
nitrate of lead with excess of carbonate of ammonia; according to Lefort (J.
[3] xv. 26), by precipitating with alkaline carbonates in the cold, whereas fro
solutions a hydrated salt, $3Pb''O.CO^2.H^2O$, is obtained. According to H. Rose
Ch. Pharm. lxxx. 235), the precipitate always contains hydrate of lead. Equ
quantities of nitrate of lead and neutral carbonate of sodium in cold strong solution
the compound $6Pb''CO^3.Pb''H^2O^2 +$ aq., which gives off some of its water at 1
and takes up more carbonic acid; with cold dilute, or hot concentrated solution
compound $5Pb''CO^3.Pb''H^2O^2$ is obtained, and with hot dilute solutions 3
$Pb''H^2O^2$. When the carbonate of sodium is added in excess, the precipitate c
chiefly of $2Pb''CO^3.Pb''H^2O^2$ or $Pb^3H^2C^2O^8$, but contains a small quantity of so

Hydrated carbonates of lead are also formed by the direct action of carbonic
hydrate of lead, and the compounds thus obtained differ from the precipitated
nate, in being amorphous and perfectly opaque, whereas the precipitated carbo
an aggregate of minute transparent crystalline grains. Hence the carbonate for
absorption of carbonic acid is much better adapted for a pigment, and is extensive
as such under the name of *white lead* or *ceruse*; its great opacity gives it that
which painters call *body*, enabling a small quantity of it to form a brilliant whit
ing over a considerable surface.

There are two methods of preparing white lead. In the older, called the
method, because it was originally practised in Holland, thin sheets of lead are
over gallipots containing weak acetic acid (water with about 2½ per cent of the
acid), the pots being embedded in fermenting tan, the temperature of which vari
140° to 150° F. The action is often very rapid, the metal disappearing in a few
to the centre of the sheet. In this process from 2 to 2½ tons of lead (4480 to 5
are converted into carbonate by a quantity of vinegar containing not more than
of strong acetic acid. It is evident, therefore, that the metal is neither oxidi
carbonated at the expense of the acetic acid. The oxygen is derived from the
the carbonic acid from the fermenting tan; the acetic acid merely serves to disso
oxide of lead and convert it into a basic acetate, which is easily decomposed
bonic acid, the acetic acid being thereby set free to act upon another portion o
of lead. That this is really the mode of action, is shown by what takes place
more modern process, in which oxide of lead (litharge) is mixed with water and
1 per cent. of neutral acetate of lead, and carbonic acid gas is passed over it:
manner the oxide is quickly converted into excellent white lead. Nitrate of l
also been used in this latter process in place of the acetate.

White lead is a mixture or compound of carbonate and hydrate of lead, in
proportions. Mulder (Ann. Ch. Pharm. xxxiii. 242), from the analysis of nu
samples, concluded that there are three varieties of it, viz.: $2Pb''CO^3.Pb$
$5Pb''CO^3.3Pb''H^2O^2$, and $3Pb''CO^3.Pb''H^2O^2$. J. A. Phillips (Chem. Soc. Q
165) found the composition of four samples to agree with the first of these f
one with the third, and another to contain $5Pb''CO^3.PbH^2O^2$.

White lead is often mixed with heavy spar and gypsum, the addition o
renders it less liable to be blackened by the action of sulphuretted hydrogen.

of zinc is likewise added for the same purpose. (Gm. iv. 127. *Ure's Dictionary of Arts, Manufactures and Mines*, iii. 1015; *Graham's Chemistry*, 2nd edition, ii. 120.)

Acid Carbonate.—Carbonate of lead dissolves slightly in water containing carbonic acid; the solution contains from $\frac{1}{3000}$ to $\frac{1}{5000}$ of lead-oxide, is rendered turbid by alkaline carbonates, and coloured brown by sulphuretted hydrogen. (See LEAD.)

Carbonate of Lead and Sodium. $4Pb''CO^3.Na^2CO^3$.—Produced, according to Berzelius (Pogg. Ann. xlvii. 199), when nitrate of lead is precipitated by carbonate of sodium, the precipitate boiled in the alkaline liquid, then washed and dried at 160° C.

CARBONATE OF LITHIUM, Li^2CO^3.—This salt, which is slightly soluble in water, exists in the waters of Carlsbad, Franzensbad, and others. It is prepared by dissolving an excess of carbonate of ammonia in a concentrated solution of chloride of lithium, and washing the resulting precipitate with alcohol; or by precipitating sulphate of lithium with acetate of barium, evaporating the filtrate, and decomposing the residual acetate of lithium by ignition. The salt melts at a low red heat, and solidifies to a vitreous mass on cooling. It is not decomposed by heat. It dissolves in 100 pts. of cold water (Vauquelin); in 130 pts. at 13° C., and in 128·5 pts. at 100° (Kremers Jahresber. d. Chem. 1856, p. 275). The saturated solution boils at 100° (Kremers *ibid.* p. 294). The solution is alkaline, and deposits the salt by slow evaporation, in small prisms. It decomposes the salts of ammonia, and gives up its carbonic acid to caustic baryta and lime.

Water saturated with carbonic acid dissolves carbonate of lithium more freely than pure water.

CARBONATES OF MAGNESIUM.—The anhydrous metacarbonate, $Mg''CO^3$, or $Mg''O.CO^2$, occurs native as *magnesite*, associated with serpentine and other magnesian rocks. It is found in rhombohedral crystals, isomorphous with calcspar. Ratio of the principal axis to the secondary axes = 0·8117 : 1. Angle of the terminal edges = 107° 25. Cleavage perfect parallel to the rhombohedral faces. It also occurs massive, granular, or fibrous, sometimes in radiating groups; also very compact. Specific gravity = 2·8 to 3. Hardness = 3·5 to 4·5. It is white, or with various shades of yellow, grey, and brown, has a vitreous or silky lustre, and exhibits all degrees of transparency, down to complete opacity. Fracture flat, conchoïdal. It is infusible before the blowpipe, and dissolves slowly and with little effervescence in acids. It occurs nearly pure, with only small quantities of water and the carbonates of iron, manganese, and calcium, in Moravia, Styria, Silesia, Piedmont, Spain, and at several localities in the United States. Carbonate of magnesium occurs also associated in various proportions with the carbonates of iron, manganese, and calcium, forming the minerals sphærosiderite, diallogite, dolomite, bitter spar, &c.

Anhydrous metacarbonate of magnesium cannot be prepared by precipitating a soluble magnesium-salt with an alkaline carbonate, as the precipitate thus formed always contains hydrate of magnesium; but by suspending the washed precipitate in water, passing carbonic acid gas through the liquid till the precipitate is dissolved, and evaporating the solution by heat, the anhydrous salt is obtained as a crystalline powder, which when examined by the microscope, exhibits the form of arragonite (H. Rose, Pogg. Ann. xlii. 366). It is likewise obtained by heating sulphate of magnesium with carbonate of sodium, to 160° C. in a sealed tube, or by enclosing a soluble magnesium-salt, together with an alkaline dicarbonate supersaturated with carbonic acid, in a strong vessel closed by a cork, through which the carbonic acid can escape slowly. By this last method, it is obtained in microscopic rhombohedrons, like native magnesite (Sénarmont, Compt. rend. xxviii. 693; Ann. Ch. Phys. [3] xxx. 129). Anhydrous carbonate of magnesium is therefore isodimorphous with carbonate of calcium. When moistened with water, it gives an alkaline reaction with litmus and violets. If the solution of carbonate of magnesium in excess of carbonic acid be left to evaporate spontaneously, or kept fcr some time at 50° C., it deposits small hexagonal prisms, containing $Mg''CO^3 + 3aq.$: they give up their water in warm air, becoming opaque, but retaining their form. The same hydrated crystals are obtained by mixing the solutions of sulphate of magnesium and sesquicarbonate of potassium and sodium, and leaving the mixture to stand. A saturated solution of carbonate of magnesium in aqueous carbonic acid, exposed for some time to a winter temperature, deposits transparent oblique prismatic crystals, containing 5 at. water; $Mg''CO^3 + 5aq.$ They are converted into the preceding, with loss of transparency, by exposure to the air, more quickly in sunshine, and by immersion in water at 50° C. If boiled with water, they give up part of their carbonic acid, and are ultimately converted into $2Mg''CO^3.MgH^2O^2 + 2aq.$ (Fritzsche.)

Hydrocarbonates. a. $5Mg''O.4CO^2 + 5aq. = 4Mg''CO^3.Mg''H^2O^2 + 4aq. = (Mg''^5H^6)C^4O^{16} + aq.$—Produced, as just mentioned, by the action of water on $Mg''CO^3 +$

5aq., better by boiling with water containing ammonia (Fritzsche); also by
pitating sulphate of magnesium with carbonate of sodium, and drying the preci
at 100° C. (H. Rose, Ann. Ch. Pharm. lxxx. 234); also, according to Berzeli
boiling a solution of acid carbonate of magnesium for a long time. It is a
granular powder.

b. $4Mg''O.3CO^2 + 4aq. = 3Mg''CO^3.Mg''H^2O^2 + 3aq. = (Mg^4H^4)C^3O^{12} + 2aq.$—
native as *Hydromagnesite*, in small white, brittle, or acicular crystals, of the mono
system, or in chalky crusts. Specific gravity = 2·145 to 2·18. Hardness of the
tals = 3·5. It is found at Hrubschitz in Moravia in serpentine; in Negropont
Kumi; and crystallised with serpentine and brucite (hydrate of magnesium), i
caster county, Pennsylvania. *Lancasterite* is a mixture of brucite and hydromag
(Dana, ii. 456.)

A substance of the same composition is obtained by mixing sulphate of magn
with excess of a hot solution of carbonate of potassium, and boiling the prec
with fresh quantities of water, as long as any acid carbonate dissolves out (Berze
also, according to Fritzsche, by boiling a saturated solution of the acid carbonat
twice boiling the resulting precipitate with fresh quantities of water. It is a
powder, slightly soluble in water, and forming an alkaline solution. When dr
100° C. in the air, it absorbs carbonic acid, and is converted into $5Mg''O.4CO^2$
(H. Rose.)

c. $3Mg''O.2CO^2 + 3aq.$ (?) Obtained, according to Fritzsche (Pogg. Ann.
310), by precipitating sulphate of magnesium with a very large excess of carbon
sodium, boiling the whole till the precipitate passes from the flocculent to the gr
condition; then washing and boiling rapidly with water, pouring off the liqui
twice boiling the residue with fresh water. It consists of small grains mixed
small quantity of the original flocculent precipitate. According to Berzelius, th
cipitate obtained as above may contain carbonate of sodium. According to H. R
precipitate formed by carbonate of sodium with sulphate of magnesium always co
$5MgO$ to $4CO^2$, whatever may be the temperature and strength of the solutions

The pharmaceutical preparation known as *Magnesia alba*, is a mixture of the
hydrocarbonates of magnesium, the proportions depending on the relative quan
the precipitant, the degree of dilution, and the temperature at which precip
takes place. It is prepared on the large scale by precipitating sulphate, nitr
chloride of magnesium with carbonate of potassium or sodium. Various m
waters containing sulphate of magnesium, such as the Epsom water, are used
purpose, also the mother-liquor of sea-water, of many salt-springs, and of many
of saltpetre; most of these liquids, however, contain lime, which must be prev
separated by sulphate of potassium or sodium. After being well washed wi
water, it forms a very light, and bulky powder. The utmost degree of lightness
tained by allowing the precipitate to freeze while still moist. (Gm. iii. 228.)

Acid Carbonate.—Magnesia alba shaken up with aqueous carbonic acid, f
solution having a bitter taste and alkaline reaction, and containing, according t
beiran, just twice as much carbonic acid with the same quantity of magnesia
normal salt (probably $Mg''H^2C^2O^6$). It becomes turbid at 75° C., but recov
clearness on cooling. When heated to 50° C., or evaporated in vacuo, it depos
trihydrated metacarbonate, $Mg''CO^3 + 3aq.$ (Berzelius, Fritzsche.)

Carbonate of Magnesium and Ammonium, $Mg''(NH^4)^2C^2O^6 + 4H^2O$
tallises in translucent rhombohedrons from a mixture of the cold aqueous soluti
sulphate or chloride of magnesium and sesquicarbonate of ammonia, the la
excess, or from a solution of hydrate of magnesium in sesquicarbonate of ammo

Carbonate of Magnesium and Potassium, $(Mg^2K^2H^2)C^4O^{12} + 8aq.$,
posited after a few days in large crystals from a cold aqueous mixture of chlo
nitrate of magnesium with excess of diacid carbonate of potassium. The crystals
opaque and lose water at 100° C., and are decomposed by water, which dissolv
acid carbonates of potassium and magnesium, and leaves a residue consisting
hydrocarbonate $6Mg''CO^3.Mg''H^2O^2 + 6aq.$ (Berzelius.)

H. Deville (Ann. Ch. Phys. xxxiii. 75) obtained the salt by the same pro
microscopic crystals, apparently having the form of oblique rhombic prisms. B
sesquicarbonate of potassium instead of the diacid carbonate, he obtained, togeth
the preceding, another double salt, containing $Mg''H^2C^2O^6 + 4aq.$ The latter is o
separately in small rhombic prisms by digesting *magnesia alba* for twelve or
hours at 60° or 70° C., with diacid carbonate of potassium.

Carbonate of Magnesium and Sodium, $Mg''Na^2C^2O^6$, is obtained in an
microscopic crystals by digesting *magnesia alba* in like manner with diacid carbo
sodium. A mixture of a magnesium-salt with diacid carbonate of sodium yi
double salt, but only $Mg''CO^3 + 3aq.$

CARBONATE OF MANGANESE.—The anhydrous carbonate occurs native

called ***Red Manganese, Rhodochrosite, Brown Spar, Manganspath.*** It
ohedral crystals, isomorphous with calcite, in which the principal is to
axes as 0·8117 : 1, and the inclination of the faces meeting in the terminal
° 51′. The crystals are tabular, exhibiting the faces R . $-\frac{1}{2}$R ∞R . 0R.
in globular and botryoïdal forms; likewise granular massive; occasionally
ble powder. Specific gravity 3·4 to 3·6; of a variety from Kapnik, 3·592.
to 4·5. It is translucent, of rose-red or brownish colour, and vitreous lustre
early. Streak white. Fracture uneven. Brittle. It is found in the Saxon
gjày and Kapnik, in Transylvania, near Elbingerode in the Harz, &c. At
the county of Clare, Ireland, it forms a layer of yellowish-grey colour,
ick, below a bog. It also occurs in the pulverulent form, coating triplite,
on, Connecticut. It is generally mixed with the carbonates of calcium
um, the proportion of carbonate of manganese varying from 97 to 75 per
ple from Ireland, analysed by Gruner (Ann. Min. [3] xviii. 61), gave
. $Mn''CO^3$, 0·7 $Fe''CO^3$, 1·0 $Ca''CO^3$, 0·8 $Mg''CO^3$, and 0·1 Mn^2O^3.

carbonate of manganese may be obtained artificially as a very fine
aintly rose-coloured powder, by heating chloride of manganese in a sealed
bonate of sodium to 160° C., or with carbonate of calcium to 140°—170°
hours. (Sénarmont, Compt. rend. xxviii. 693.)

tating manganous salts with carbonate of potassium or sodium, a white
formed, which, after washing with boiling water, and drying in vacuo
itriol, is a snow-white tasteless powder, containing, according to the
Jre, Turner, John, and Forchhammer, $2Mn^2CO^3 + aq.$ (Gm. iv. 214).
H. Rose (Ann. Ch. Pharm. lxxx. 235) equivalent quantities of chloride
and carbonate of sodium yield a precipitate containing $5Mn^2CO^3.2MnHO$
of manganese, whether anhydrous or hydrated, is permanent at ordinary
but when heated to redness in the air, assumes a dark brown colour, and
into manganoso-manganic oxide. Ignited in an atmosphere of hydrogen,
nish-grey manganous oxide. Ignited in chlorine gas, it yields, according
crystalline mixture of chloride of manganese and manganoso-manganic

$$4Mn''CO^3 + Cl^2 = Mn''Cl^2 + Mn^3O^4 + 4CO^2.$$

er or aqueous hypochlorite of calcium converts it, first into manganoso-
de, afterwards into peroxide. When recently precipitated, it dissolves in
alts. It is soluble in 7680 pts. of pure water, and in 3480 pts. of aqueous
. (John.)

TES OF MERCURY.—*Mercuric* nitrate gives with neutral or acid car-
tassium or sodium, a brown-red precipitate, containing $4Hg''O.CO^2$, or
O^3. (Setterberg, Pogg. Ann. xix. 60.) From mercuric chloride, alkaline
precipitate, not a carbonate but an oxychloride.

nitrate yields with carbonate of potassium a black or yellow powder,
mercurous carbonate, $(Hg^2)''CO^3$. It is very apt to give off carbonic acid;
way of obtaining it of definite composition is to mix mercurous nitrate
excess of alkaline bicarbonate, set the mixture aside for a few days, and
ntly, then wash as quickly as possible, and dry in vacuo over oil of vitriol.
g, *loc. cit.*) It is converted into mercuric oxide by exposure to the air.
en it, separating metallic mercury. (Gm. vi. 15.)

S OF METHYL. See CARBONIC ETHERS.

TE OF NICKEL.—The anhydrous salt, $Ni''CO^3$, is obtained by heating
ckel with alkaline carbonates in sealed tubes, in the same manner as car-
alt (p. 782), is a greenish-white crystalline powder, composed of minute
ns, scarcely attacked by strong acids at ordinary temperatures. (Sénar-

rbonate of nickel, $Ni''CO^3.2Ni''H^2O^4$, called ***Emerald-nickel***, occurs in the
actitic crust on chrome-iron ore, at Texas, Lancaster County, Pennsylvania,
ness in Unst, Shetland. It is amorphous, with an uneven somewhat scaly
ecific gravity = 2·67 to 2·623. Hardness 3 to 3·25. Colour, emerald-
rong vitreous lustre. Streak green. It gives off water when heated, and
h. (B. Silliman, Jun. Sill. Am. J. [2] vi. 248.)

kelmagnesite, a mineral allied to the preceding, but containing magnesium
ckel, is found in the same localities in serpentine. (Shepard *ibid.* 250.)
s treated with alkaline carbonates, yield a pale apple-green, flocculent
which, after washing and drying, sometimes forms a loose, earthy, pale-
aving a faint metallic lustre, sometimes, especially after continued wash-
ing water, a thick blackish-green mass, having a conchoïdal wavy fracture.
ates thus formed always contain water, their composition varying according

to the temperature, strength, and proportions of the solutions employed. Accordi
H. Rose (Ann. Ch. Pharm. lxxx. 237), the precipitate formed in the cold with sulp
of nickel and neutral carbonate of sodium consists, when dried at 100° C., chief
$2Ni''CO^3.3Ni''H^2O^2 + 4aq.$; if boiled with a large quantity of water, it appear
take up water and lose carbonic acid. If heated in the air above 100°, it gradu
gives off carbonic acid and water, and is partly converted into peroxide of ni
Precipitated carbonate of nickel does not appear to be altered by digestion
bicarbonate of soda, even at 60° to 70°. (H. Deville.)

Carbonates of Nickel and Potassium.—By methods similar to those adopted
the corresponding cobalt-salts (p. 782), Deville obtained the salt $(Ni''K^2)C^2O^6$ +
in shining apple-green microscopic needles, and $(Ni''KH)C^2O^6 + 4aq.$ in light
crystals, apparently having the form of oblique rhombic prisms. The last was
obtained by Rose.

Carbonate of Nickel and Sodium, $(Ni''Na^2)C^2O^6 + 10aq.$, is obtained like the co
salt, in small crystals, which appear to be cube-like rhombohedrons. (Deville.

CARBONATES OF PALLADIUM.—On adding an alkaline carbonate to a solutio
palladium, a light yellow precipitate is formed, at first without evolution of carb
anhydride; but on continuing the precipitation, effervescence ensues, and the precipi
turns brown. It retains a small quantity of carbonic acid when dry. (Berzeliu

CARBONATES OF POTASSIUM.—Three of these salts are known, all having
constitution of metacarbonates, viz. the *dipotassic* or *neutral carbonate*, K^2CO
$K^2O.CO^2$, the *monopotassic* or *di-acid carbonate*, commonly called *bicarbonate*, KH
or $K^2O.H^2O.2CO^2$, and the *tetrapotassic* or *sesqui-acid carbonate*, $K^4H^2C^3O$
$2K^2O.3CO^2 + H^2O$. The last has not been obtained in very definite form, an
perhaps only a mixture of the other two.

Dipotassic Carbonate, or *Neutral Carbonate of Potassium.* K^2CO^3.
carbonate of Potash. Mild or *Aërated Vegetable Alkali. Salt of Tartar. Purified Po*
Pearlash. Alkali vegetabile fixum. Cineres clavellati depurati.—This salt is obta
chiefly from the ashes of plants. Living plants contain the potassium-salts of se
vegetable acids, acetic, malic, tartaric, oxalic, &c.; and these salts, when calcined
transformed into carbonate, which remains in the calcined residue mixed with cha
and the various mineral salts contained in the plant, viz. sulphate, chloride,
silicate of potassium and sodium, besides carbonate of calcium and other insol
matters. On treating the ash with water, the carbonate of potassium is dissol
together with the alkaline sulphates and chlorides, and a residue is left, consistin
carbonate and phosphate of calcium, silica, clay, &c. The solution is evaporate
dryness, and the residue is sold as crude potash. Sometimes lime is stirred in
the solution during the evaporation, and then the carbonate of potassium is partly
verted into hydrate or caustic potash. The quantity of potash obtained from
rent plants varies according to their nature, the most succulent yielding the la
amount, inasmuch as the alkaline salts are chiefly contained in the sap: hence herba
plants yield more than shrubs or trees. The different parts of the same plant
yield different quantities—the leaves more than the branches, the bark more tha
wood.

The ashes of plants are used in all countries for the alkali which they contain,
as manure for the soil, and to yield a lye for the bleaching of linen; but it is on
countries where wood is very abundant, that potash can be advantageously prepar
a commercial product. Nearly all the potash used in the arts comes from Ameri
from Russia.

Crude potash contains from 60 to 80 per cent. of carbonate of potassium, th
mainder consisting of sulphate, chloride, and small quantities of silicate of potas
together with organic matter which has not been completely burnt. This carb
being much more soluble than the other potassium-salts, may, for the most pa
separated from them by digesting the crude potash for several days with its own w
of cold water, then decanting the liquid, quickly evaporating it, removing it from th
as soon as it begins to show turbidity from the formation of small crystals, and leav
to cool, stirring all the while to prevent the formation of large crystals, which
enclose mother-liquor in their cavities. The mother-liquor is then filtered off
crystals washed with a small quantity of solution of pure carbonate of potassium,
dried and heated to incipient redness in vessels of cast-iron, silver, or platinum.
product thus obtained, called pearlash, contains only 2 or 3 per cent. of fo
matter, which, however, is difficult to remove.

Pure carbonate of potassium may be obtained by igniting acid tartrate of potas
(cream of tartar) in a crucible. A black residue is thereby obtained, consistin
carbonate of potassium and charcoal, which is often used as a reducing agent,
the name of *black flux.* The carbonate of potassium is separated from the charco

ter, filtration, and evaporation. If the solution has a brown colour from l organic matter, the salt must be again ignited.

of potassium is sometimes prepared by throwing into a red-hot iron ll portions at a time, a mixture of 1 pt. cream of tartar and 2 pts. nitre. f the cream of tartar is then all burnt away by the oxygen of the nitre, ains a white mass called *white flux*, consisting almost wholly of carbonate It frequently, however, contains small quantities of nitrite,—which may diminishing the proportion of nitre used,—and always a little cyanide

nate of potassium is, however, more easily obtained from the acid carlate (binoxalate). The acid carbonate, $KHCO^3$, is found in commerce in very nearly pure. It may be further purified by recrystallisation, and, in a platinum or silver crucible, yields the pure neutral carbonate. The f potassium may be prepared by mixing hydrate of potassium with excess , and purified by several crystallisations. When ignited, it leaves pure potassium unmixed with charcoal. (Regnault.)

ties which may occur in commercial carbonate of potassium are the fol*hate of potassium:* detected by the turbidity produced on adding chloride the solution acidulated with hydrochloric acid and diluted. *Chloride of* loud produced by nitrate of silver in the solution acidulated by nitric *hate of potassium:* crystalline precipitate by sulphate of magnesium in ed first with hydrochloric acid, then with excess of ammonia. *Nitrate or assium:* reddish brown colour by ferrous sulphate in solution of the salt ulphuric acid. *Cyanide of potassium:* Prussian blue, formed by ferrosoe and excess of hydrochloric acid. *Soda:* crystalline precipitate with nonate of potassium (p. 327). *Carbonate of calcium:* retained in solution, h the medium of the carbonate of potassium: cloud with oxalic acid after with acetic acid. *Silica:* remains undissolved on acidulating with acid, evaporating to complete dryness, and digesting the residue in dilute acid. *Oxide of copper:* red-brown precipitate with ferrocyanide of potaslated solution.

of potassium is very soluble in water, 1 pt. of the anhydrous salt disrding to Osann, in 1·05 pt. of water at 3° C. (37·4° F.), in 0·9 pt. at 12·1°C. in 0·49 pt. at 70° C. (158° F.) The most concentrated solution, containcent. of the anhydrous salt, has a specific gravity of 1·54 at 15° C., and C. (235·4 F.) (Dalton). It has a strong alkaline taste and reaction, but tly corrosive. A highly concentrated hot solution deposits on cooling hedrons containing 20 per cent. of water, corresponding to the formula l.

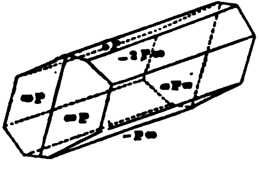
rystals and the anhydrous salt deliquesce rapidly in the air, forming an The anhydrous salt melts at a red heat, volatilises at a white heat. It is sed by any temperature in close vessels; but at a red heat, not sufficient is partly decomposed and converted into hydrate by a stream of aqueous ist air; it is not decomposed by dry air or dry hydrogen gas. Charcoal, at heat, decomposes it, with separation of potassium and formation of carand other products (see POTASSIUM). The aqueous solution, containing 10 pts. of water to 1 pt. of the dry salt, is decomposed by lime at ordiitures, and more quickly at the boiling heat, the carbonic acid being reaustic potassa produced. With more concentrated solutions, the reverse place, caustic potassa abstracting carbonic acid from carbonate of calcium.

of potassium is much used in chemical manufactures, especially for the f soft soap, in glass making, and in the preparation of cyanide of potasanide of potassium, Prussian blue, &c.; also for the preparation of nitrate from the nitrates of sodium, magnesium, and calcium.

assic Carbonate, or *Di-acid Carbonate of Potassium.* $KHCO^3$ = O^2. *Bicarbonate of Potassa. Berthollet's neutral Carbonate of Potassa.*—btained by passing carbonic acid gas to saturation into a solution of 1 pt. ercial neutral carbonate in 4 or 5 pts. of water. Crystals of the acid carform, and may be purified by washing with a small quantity of cold water. t precipitate should form at first, consisting of alumina or silica, it must by filtration. The carbonic acid evolved in alcoholic fermentation, or that me localities escapes from the soil, may be utilised for this purpose. A ay of preparing the acid carbonate is to expose the mixture of neutral carcharcoal, obtained by calcining cream of tartar and slightly moistened with action of carbonic acid gas; the presence of the charcoal greatly facilisorption of the carbonic acid. The acid carbonate is dissolved out from the charcoal by boiling water and left to crystallise (Wöhler. Ann. Ch. Pharm. 49). It must not be boiled in iron vessels, as it would dissolve a small quantity c iron.

Acid carbonate of potassium crystallises in large rhomboïdal prisms belongi the monoclinic system. Ratio of orthodiagonal to clinodiagonal to principal ax 0·3734 : 1 : 0·491. Inclination of clinodiagonal to principal axis = 76° 35′. crystals often exhibit the faces ∞P . 0P . ∞P∞ . −P∞ . + 2P∞ (*fig.* 125), the −P∞ frequently predominating so far as to oblit the adjacent faces. ∞P : ∞P = 138°. Cle parallel to ∞P∞, −P∞, and 0P. The crystals tain no water of crystallisation. When heate 100° C., they give off water and carbonic anhy and are reduced to neutral carbonate: $2KHCO^3 -$ $-CO^2 = K^2CO^3$.

Fig. 125.



Acid carbonate of potassium is much less solul water than the neutral carbonate. 100 pts. of dissolve of it, according to Poggiale:

At 0° C.	19·61 pts.	At 50° C.	37·92 pts
„ 10	23·33 „	60	41·35 „
„ 20	26·91 „	70	45·24 „

The aqueous solution when boiled gives off carbonic acid, and is gradually ch into neutral carbonate. The decomposition is sufficiently slow to admit of the fication of the acid carbonate from a boiling solution without much loss.

It dissolves but sparingly in boiling alcohol, only indeed to the amount of 1 1200.

The aqueous solution of acid carbonate of potassium, mixed with the salts of metals, generally forms double carbonates (pp. 782—788). It does not precipitate nesium-salts in the cold, a character by which it is readily distinguished from the n carbonate.

Acid carbonate of potassium is much used in chemical operations where a potassium-salt is required, as it is very easily obtained in a pure and definite state is also used in medicine, in cases of gout and uric acid gravel.

Sesquicarbonate of Potassium?—A salt intermediate in composition between th preceding, was said by Berthollet to be obtained in crystals, by mixing 100 pts. neutral with 131 pts. of the acid carbonate (1 at. K^2CO^3 with 2 at. $KHCO^3$), heating a solution of the di-acid carbonate as long as carbonic acid goes off; b cording to H. Rose (Pogg. Ann. xxxiv. 149), the latter process yields almost neutral carbonate of potassium. The salt prepared by the first process should co $K^4H^2C^3O^9$, or $2K^2O.3CO^2 + H^2O$; but its existence does not appear to have been factorily proved.

Carbonate of Silver, Ag^2CO^3, is produced by precipitating nitrate of with an alkaline carbonate. It is white at first, but becomes yellow when the s salts are washed out, and blackens when exposed to light or gently heated. It dis readily in strong ammonia, and the solution treated with absolute alcohol yields cipitate containing ammonia and carbonate of silver. (Berzelius.)

At 200° C. it gives off carbonic anhydride, and leaves pure oxide of silver, begins to give off oxygen at 250°. By precipitating nitrate of silver with a large of alkaline carbonate and boiling, a basic carbonate is obtained, having, when dr 100°, the composition $3Ag^2O.CO^2$, or $Ag^2CO^3.2Ag^2O$, perhaps only a mixture. (H. Ann. Ch. Pharm. lxxxiv. 202.)

Carbonates of Sodium.—Three of these salts are known, correspondi composition to the potassium salts.

Disodic Carbonate, or ***Neutral Carbonate of Sodium***, Na^2CO^3. *S bonate of Soda. Soda. Mild mineral alkali. Alkali minerale fixum.*—This salt exi the soda-lakes of Egypt and Hungary, and in the volcanic springs of Iceland, & also frequently occurs. mixed with sulphate of sodium, in the form of an efflores on walls, being formed from sodium-salts contained in the mortar. It is largely in the arts, and was formerly obtained from *barilla*, the ash of *Salsola soda* and plants growing on the sea-shore, and from the ash of sea-weed called *kelp:* but present day, nearly all the soda of commerce is obtained from common salt, by a p invented by Leblanc, towards the end of the last century, and perfected by D'A and D'Arcye. This process consists of three stages:

1. The conversion of chloride of sodium into sulphate by heating it with sulp acid.

2. The conversion of the sulphate into carbonate by heating it in a reverbe

lk or limestone and coal. The materials are mixed in the proportion f dry sulphate of sodium, 3½ pts. chalk, and 2 pts. coal. The sulphate uced to sulphide, with evolution of carbonic oxide; and the sulphide verted by the carbonate of calcium into carbonate of sodium and sul- which, by taking up lime, is for the most part converted into an in- ide of calcium:

$$^2SO^4 + 3Ca''CO^3 + C^9 = 2Na^2CO^3 + Ca^2S^2O + 10CO.$$

onic acid is, however, driven off from the lime by the heat, before it lphide of sodium, and consequently, the fused mass contains, besides ium, a variable but always large amount of caustic soda.

is obtained by this process, has the appearance of dark-grey, half- ence called "black balls,"—being brought into this form by stirring i-fused state. It varies considerably in composition, as the following w, one of a sample from Cassel analysed by Unger, another from New- dson.

Composition of Black Balls, or Crude Soda.

	Cassel.	Newcastle.
ate of sodium	23·57	9·89
soda	11·12	25·64
e of sodium	1·99	3·64
e of sodium	2·54	0·60
ate of calcium	12·90	15·67
phide of calcium	34·76	35·57
e of iron	2·45	1·22
of magnesium	4·74	0·88
l	1·59	4·28
	2·02	0·44
	2·10	2·17
	99·78	100·00

.—The crude or ball soda, after being crushed under millstones and l and disintegrated by hot vapour, is lixiviated with warm water, which arbonate of sodium and the other soluble salts, leaving the oxysulphide solved. To effect the extraction with the smallest possible quantity de soda is placed in perforated sheet-iron boxes, suspended just below he liquid, and is subjected to a continuous process of exhaustion in a ing tanks, arranged somewhat like the pans for the evaporation of 7). Each box containing the crude soda is first suspended in the which contains a nearly saturated lye, then transferred to the next, somewhat weaker lye, and so on till it arrives at the highest, into which mitted from a cistern. When the lye in the lowest tank is saturated, to the evaporating pan, its place being supplied by that in the next, is replaced by the third, &c. In this manner, each portion of liquid saturated, and the ball soda completely exhausted of soluble salts. l solution is boiled down to dryness, and yields a salt consisting chiefly sodium mixed with caustic soda and sulphide. This is called *soda-*

his product further, it is mixed with one-fourth of its bulk of sawdust, a low red heat in a reverberatory furnace, for about four hours: the oduced by the combustion of the sawdust, then converts the caustic ate; also the sulphide, with evolution of sulphuretted hydrogen. This about 50 per cent. of alkali, and forms soda-salt of the best quality.

rystallised carbonate, the purified soda-salt is dissolved in water, and clarified is boiled down till a pellicle forms on the surface. The solu- into shallow crystallising vessels, and after standing for a week, the drawn off, and the crystals are drained and broken up for the market. obtained contain 10 at. of water. The mother-liquor, which contains is evaporated to dryness for soda-salt.

ation of carbonate of sodium generally affords a safe guarantee of its tals also dissolve in water much more quickly than the anhydrous salt, e more convenient for many purposes. But when the salt is required s state, as for glass-making, or as a flux in metallurgic operations, or ntities are wanted, as in the soap-manufacture, the soda-salt is preferred, tity of water in the crystals (nearly 63 per cent.) greatly increases the t. For some purposes, the crude soda as it leaves the furnace is suffi-

ciently pure. In preparing it to be sold for such purposes, sulphate of sodium
containing 10 to 12 per cent. of common salt; this remains unchanged in the s
communicates to it the property of easily falling to pieces in damp air, thus c
the necessity of grinding.

For further details respecting the soda-manufacture, see *Miller's Chemistry,*
Ure's Dictionary of Arts, Manufactures, and Mines, iii. 720; *Chemica*
nology, by Richardson and *Watts;* Payen, *Précis de Chimie industrielle,*
i. 296.

Other methods of obtaining carbonate of sodium from the chloride have b
posed, but none of them appear to be able to compete with that above desc
1. Sulphate of iron produced by the oxidation of iron pyrites, is a cheap art
has been proposed as a substitute for sulphuric acid in the first stage of the
sulphate of sodium and chloride of iron are formed, the latter volatilising; or
salts are dissolved together in water, and the solution is exposed to a low temp
whereupon sulphate of sodium crystallises out, while chloride of iron remains
tion; or the sulphate of sodium may be made to crystallise out by raising th
to the boiling point.—2. Sulphate of sodium may be formed by roasting iro
in a reverberatory furnace with common salt.—3. Sulphate of sodium is decom
a solution of caustic baryta or strontia, these earths being procured by dec
the native sulphates with steam at a red heat; the sulphuric acid thereby
might be used for converting the chloride of sodium into sulphate (Tilghm
4. Chloride of sodium is decomposed by hot steam in presence of alumina,
aluminate of sodium is formed; and the solution of this salt is decompos
current of carbonic acid gas (Tilghmann).—5. Ammonia gas is passed into a
of chloride of sodium; then carbonic acid, whereby chloride of ammonium
carbonate of sodium are produced:

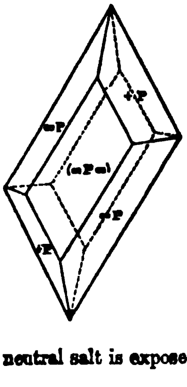
$$NaCl + NH^3 + CO^2 + H^2O = NaHCO^3 + NH^4Cl.$$

The acid carbonate of sodium being the less soluble salt of the two, crystall
it is converted into neutral carbonate by heat, and the carbonic acid evolve
again. The mother-liquor containing the sal-ammoniac is boiled, to drive off
bonate of ammonium that it may contain, and this salt is collected; the solutio
boiled with lime, to liberate the rest of the ammonia. In this manner the
may be conducted with but little loss. (Schloessing and Roland.)

The impurities found in commercial carbonate of sodium are, *sulphide, hypo*
sulphate, chloride and *ferrocyanide of sodium;* also *potassium-salts, carb*
calcium, and *carbonate of magnesium.* It may be purified by repeated crysta
or by washing the commercial crystals with cold water, dissolving them in h
stirring and cooling rapidly, to prevent formation of large crystals, then
off the mother-liquor, and washing the crystalline powder with cold water.
Lussac.)

Neutral carbonate of sodium in the anhydrous state, is a white powder con
translucent particles. It has a specific gravity of 2·4659 (Karstin). It m
moderate red heat, more easily than carbonate of potassium. It is quite u
posible by heat in close vessels, but is easily decomposed when heated to red
current of steam or moist air, less easily in a current of dry air or hydrogen (H
It is decomposed by charcoal at a bright red heat, yielding carbonic oxide and
In contact with water, it becomes heated, and forms a hydrate which disso
has an alkaline taste and reaction, but is even less cau
carbonate of potassium.

Fig. 126.



Hydrates.—There are several *hydrates* of neutral car
sodium. — *a.* The ordinary crystals which separate from
rately strong solution at ordinary temperatures, contai
(62·69 per cent.) water, $Na^2CO^3 + 10H^2O$. They belo
monoclinic system. Orthodiagonal: clinodiagonal: princ
= 0·7049 : 1 : 1·0452. Inclination of clinodiagonal = 57
dinary combination + P . ∞ P . [∞ P ∞] (*fig.* 126); ∞P
100° 20′. Cleavage tolerably distinct parallel to ∞ P ∞,
tinct parallel to [∞ P ∞]. Specific gravity = 1·423 (Hai
They effloresce in moderately dry air, crumbling to a white
and giving off 5 at. water at 12·5° C. and 9 at. at 38° (Sch
9 at. also in vacuo over oil of vitriol (Blücher). The 10-
salt occurs as a natural product called *natron,* together
mono-hydrate, at the soda-lakes of Egypt and Hungary,
vius, Etna, and in various parts of Asia, Africa, and
(Dana, ii. 455.)

a. Na^2CO^3 + 15aq. is obtained in crystals, when a soluti
neutral salt is exposed to a temperature of − 20° C., and the frozen water is af

allowed to liquefy; and $Na^2CO^3 + 9aq.$ by repeatedly crystallising a solution which at first contains a portion of acid carbonate. (Jacquelain, Compt. rend. xxx. 106.)

b. $Na^2CO^3 + 8$ aq. crystallises in right rhombic prisms with four-sided summits, when the 10-hydrated salt is melted and left to cool, or from a hot-saturated aqueous solution, apparently at a temperature lower than the crystallising point of the mono-hydrated, and higher than that of the deca-hydrated salt. (Thomson, *Annals of Philosophy*, 26, 44.)

c. $Na^2CO^3 + 7aq.$—This hydrate crystallises in two forms, (*a*) rhombohedral; (*b*) in trimetric crystals of the same form as Thomson's salt (which, according to Loewel, contains, not 8 at. but 7 at. water). When a solution saturated at the boiling heat is enclosed in a flask, which is corked immediately after the boiling has ceased, no crystals are deposited from it for a long time on cooling down to between 25° and 18° C.; but on cooling below 8° it deposits chiefly the trimetric 7-hydrated salt. Between 16° and 10°, it yields the rhombohedral salt (*a*), which redissolves between 21° and 22°, forms again at 19°, and on cooling from 10° to 4° becomes opaque, and passes into *b*. After cooling to a lower temperature and for a longer time, when the state of supersaturation ceases, the whole is converted into a mass of crystals of the deca-hydrated salt. (H. Loewel, Ann. Ch. Phys. [3] xxxiii. 334.)

d. $Na^2CO^3 + 6aq.$ crystallises from a solution of protosulphide of sodium exposed to the air, and frequently also from a mixed solution of carbonate of potassium and chloride of sodium. (Mitscherlich, Pogg. Ann. viii. 441.)

e. $Na^2CO^3 + 5aq.$ is formed when the 10-hydrated salt effloresces at 12·5° C. (Schindler), also when the same salt is melted in its water of crystallisation, and after the mono-hydrated salt has crystallised out between 70° and 80° C., the remaining liquid is kept for some time at 34°; it is also formed from the mono-hydrated salt by exposure to the air (Berzelius). It was once accidentally obtained at the Buxweiler soda works, in transparent rhombic octahedrons, which effloresced slightly in the air, and when dissolved in water and evaporated at 30° C. yielded the same salt. (Persoz, Pogg. Ann. xxiii. 303.)

f. $Na^2CO^3 + aq.$ is formed from the deca-hydrate by efflorescence, and is found native as *thermonatrite*, in the same localities as natron, and is indeed the more common salt of the two. It forms rectangular tables of the trimetric system with bevelled edges.

The same hydrate separates from a solution of the neutral carbonate concentrated by evaporation at the boiling heat, a circumstance which is made available in the soda manufacture for the purification of the salt, the crystalline powder which separates from the boiling solution being taken out and drained; if left to cool in the solution, it would redissolve. It does not undergo the aqueous fusion when heated, but gives off its water and becomes opaque at 87° C. It absorbs water from moist air, and is converted into the pentahydrate. In a warm atmosphere, it absorbs carbonic acid and forms sesquicarbonate.

Solution of Carbonate of Sodium.—According to Poggiale, 100 pts. of water dissolve of the anhydrous salt, 7·08 pts. at 0° C., 16·66 at 10°, 25·93 at 20°, 30·83 at 25°, 35·90 at 30°, and 48·5 at 104·6°, which is the boiling point of the saturated solution. According to Anthon, the 10-hydrated salt dissolves in 2 pts. of cold, and much less than 1 pt. of hot water. According to Loewel (*loc. cit.*) 100 pts. of a saturated solution contain of the 10-hydrated salt, 7 pts. at 0° C., 12·1 pts. at 10°, 16·2 pts. at 15°, 21·7 pts. at 20°, 28·5 pts. at 25°, 37·2 pts. at 30°, 51·7 pts. at 38°, and 45·5 pts. at 104°. Hence it appears that there is a maximum solubility at 38° C.

Solutions of carbonate of sodium are capable of assuming the state of supersaturation, like those of the sulphate. A solution saturated at the boiling heat and immediately enclosed in a sealed tube or a well corked flask, remains supersaturated at common temperatures, and frequently even when cooled several degrees below 0° C. Keeping the air in contact with the liquid from agitation, as by covering the hot solution with a glass shade, is often sufficient to prevent crystallisation at ordinary temperatures; but access of air then causes immediate solidification, attended with rise of temperature. The supersaturated solutions, as already observed, deposit the 7-hydrated salt in two different modifications, according to temperature (*vid. sup.*)

Monosodic Carbonate. Di-acid Carbonate of Sodium. Bicarbonate of Soda. $NaHCO^3$ or $Na^2O.H^2O.2CO^2$.—This salt exists in solution in alkaline mineral waters. It is prepared: 1. By passing carbonic acid gas into a solution of the neutral carbonate as long as it is absorbed.—2. By exposing the effloresced neutral carbonate placed on trays in a wooden case to an atmosphere of carbonic acid.—3. By adding commercial carbonate of ammonia (which is chiefly bicarbonate) to an equal weight of chloride of sodium, dissolved in three times its weight of water, stirring the whole well together, and leaving it to stand for several hours. Monosodic carbonate then separates in crystalline grains, while chloride of ammonium remains in solution (p. 794);

$$NaCl + NH^4.HCO^3 = NaHCO^3 + NH^4Cl.$$

The precipitate is separated from the liquid by pressure in a screw pre
always retains a portion of chloride of sodium.

Monosodic carbonate crystallises in oblique four-sided tables, and is some
tained by the first method in crystals of considerable size; the second
methods yield it in the form of a crystalline powder. It has a slight alkaline
reaction, and is permanent in dry air at ordinary temperatures. At a red he
off water and carbonic acid, and is reduced to anhydrous neutral carbonate.

100 pts. of water dissolve of monosodic carbonate, 8·95 pts. at 0° C.,
at 10°, 11·15 pts. at 20°, 12·24 pts. at 30°, 14·45 pts. at 40°, and 16·69
(Poggiale). The solution gives off carbonic acid slowly at ordinary tem
more quickly at 70° C., rapidly at the boiling heat, and is ultimately reduc
tral carbonate. It does not precipitate magnesium-salts in the cold, but at
heat carbonic acid escapes and a precipitate of carbonate of magnesium is for
character distinguishes it from the neutral carbonate. Acid carbonate of sodi
for the preparation of effervescing powders, and as a remedy in certain calculous

Tetrasodic Carbonate or *Sesquicarbonate of Sodium.* Na^4
2aq. = $2Na^2O.H^2O.3CO^2 + 2aq.$ — This salt, which may be regarded as a
of the mono- and di-sodic carbonates ($2NaHCO^3 + Na^2CO^3$), is found in Afr
province of Sakenna, two days' journey from Fezzan, where it is called
occurs at the foot of a mountain, forming a crust, varying in thickness from
that of the back of a knife; also as *urao* at the bottom of a lake in Maracai
America; efflorescences of it occur also near the Sweetwater River, Rocky
mixed with sulphate and chloride of sodium (Dana, ii. 454). It is produ
cially: 1. By mixing the mono- and di-sodic carbonates in the proportions
cated, melting them together, drying, and exposing the dried mass to th
cellar for some weeks; it then absorbs water, becomes crystalline, and conta
filled with shining crystals of tetrasodic carbonate. From a hot solution of
di-sodic carbonates, the two salts crystallise out separately on cooling (H
J. pr. Chem. xxvi. 312).—2. A solution of the monosodic salt, concentrated
but not boiled long enough to reduce it to the disodic salt, deposits the tetr
on cooling.—3. If 4 oz. of alcohol be poured on the top of a solution conta
grains of the disodic and 152 grains of the crystallised monosodic carbonate
water, fine clear needle-shaped crystals of the tetrasodic salt form, after son
the surface of separation of the two liquids, while at the bottom of the solu
crystals of the disodic carbonate are found covered by a crust of the mono
(Winckler, *Gmelin's Handbook*, iii. 83.)

The crystals of the native salt belong to the monoclinic system. Orth
clinodiagonal: principal axis = 0·3552 : 1 : 1·282. Inclination of clinodiagon
cipal axis = 53° 50′. Observed combination $\infty P . oP . + P\infty$, prismatically
in the direction of the orthodiagonal. $\infty P : \infty P = 132° 30′$. Cleavage ve
parallel to $+ P\infty$. They are colourless, transparent, or translucent, wit
lustre. Specific gravity 2·112. Hardness 2·5 to 3. Structure foliated,
fracture conchoïdal. The artificial crystals are small, and of the same fo
native crystals. The salt has an alkaline taste and reaction, and is not e
At a red heat, or when its aqueous solution is boiled for many hours, it is redu
neutral carbonate. It is intermediate in solubility between the two prece
According to Poggiale, 100 pts. of water dissolve of it, 12·63 pts. at 0° C., 1
20°; 38·95 pts. at 40°; 29·68 pts. at 60°; 35·80 pts. at 80°; and 41·59 pts. at
solution is not rendered turbid by 1 pt. of sulphate of magnesium dissolved
of water. Evaporated in vacuo over oil of vitriol, it yields a mass of crystals
of the mono- and di-sodic carbonates together. (H. Rose, Pogg. Ann. xxx

Carbonate of Sodium and Potassium. $KNaCO^3 + 6aq.$—Separ
a solution containing equivalent quantities of the component salts, in monocli
exhibiting the faces $\infty P . \infty P\infty . [\infty P\infty] . \infty P2 . [\infty P2] . 0P . + P .$
$P\infty . + 2P\infty [P\infty] . + 2P\infty$. Inclination of faces; $\infty P : \infty P$ in the cli
principal section = 108° 34′; $0P : \infty P\infty = 131° 48′$; $0P : \infty P = 122°$
$+ P\infty = 124° 48′$; $0P : + 2P\infty = 84° 19′$ (Marignac, Compt. rend.
Nearly the same angular values were observed by Sénarmont. The crystal
manent in the air. A salt containing $K^2Na^4C^3O^9 + 18aq.$ is mentioned by
ritte (Ann. Ch. Pharm. lvi. 220) as crystallising from the mother-liquor
cyanide of potassium, and from a concentrated solution of the simple
Marignac was not able to obtain this compound, and is of opinion that the
deduced from an incorrect analysis.

A mixture of the neutral carbonates of sodium and potassium in equivale
tions, fuses at a much lower temperature than either of the salts separat
less in consequence of the formation of the double salt. Such a mixture is
in the fusion of silicates, &c.

f Sodium and Calcium, $Ca''Na^2C^2O^6 + 10aq$.—Occurs abundantly,
t Lagunilla near Merida, in Maracaibo, covering *urao;* found also at
Thuringia. The crystals are monoclinic. Inclination of axes
: ∞P = 68° 50′. Cleavage perfect parallel to ∞P : less perfect
They are yellowish-white, translucent, double refracting, extremely
hoïdal fracture, and exhibit a vitreous lustre on the broken surface.
= 1·92—1·99. Hardness = 2—3. The mineral decrepitates when
mes opaque from loss of water. In the hydrated state it dissolves
r, without decomposition; but the anhydrous salt is resolved by water
sodium and carbonate of calcium. Crystals of Gay-Lussite, altered
netimes called *natrocalcite.* (Dana, ii. 453).

e prepared by fusing the anhydrous carbonates of sodium and calcium
c proportions.

lts of carbonate of sodium with other metals, magnesium, cobalt,
cribed with the carbonates of those metals.

OF STRONTIUM. $Sr''CO^3$.—Occurs native as *Strontianite*, at
leshire, where it was first observed; also in Yorkshire, at the Giant's
usthal in the Harz, at Bräunsdorf in Saxony; Leogang in Saltzburg,
ies. It forms crystals of the trimetric system, isomorphous with
witherite. Ratio of brachydiagonal to macrodiagonal to principal
1 : 0·7237. The crystals are often prismatic from predominance of
$\bar{P}\infty$ and $\breve{P}\infty$. Cleavage tolerably perfect parallel to ∞P, less per-
P∞. Specific gravity 3·605—3·713. Hardness 3·5 to 4. Colour
us shades of grey, green, yellow, and brown. Streak white. Lustre
parent or translucent. Fracture uneven. Brittle. Before the blow-
he edges and swells up, emitting a brilliant light, and when strongly
educing flame, imparts to it a reddish tinge. Strontianite occurs
ine by the action of soluble sulphates. *Baryto-strontianite*, from
ney, appears to be a mechanical mixture of the carbonates of stron-

trontium obtained by precipitation is a white substance, smooth to
s but little cohesion. It dissolves in 18045 pts. of cold water, and in
ter containing ammonia or carbonate of ammonium (Fresenius);
f water, whether cold or hot (Bineau, Compt. rend. xli. 509); in
saturated with carbonic acid at 10° C. (Lassaigne), and in this
some mineral waters, whence it crystallises by evaporation in needle-
When heated in close vessels, it does not give off carbonic anhydride
re short of that of a forge fire; but in a stream of aqueous vapour or
omposition takes place at a lower temperature, with formation of
tium. It is not decomposed by solutions of alkaline sulphates at
(H. Rose, Pogg. Ann. xcv. 284).

OF THORINUM.—Alkaline carbonates, added to solutions of thori-
down a basic salt, with evolution of carbonic acid. Moist hydrate of
carbonic acid from the air. The anhydrous earth is not soluble in
carbonic acid. (Berzelius.)

OF URANIUM.—These salts do not appear to exist in the separate
carbonates throw down from uranous chloride a precipitate of
from uranous sulphate, a basic sulphate; from uranic salts, precipi-
f double carbonates.

ic Carbonate, $2[(NH^4)^2O.CO^2] + U^2O^3.CO^2$ or *Carbonate of Uranyl**
$\left.\begin{matrix}(NH^4)^4\\(U^2O^2)''\end{matrix}\right\} C^3O^9$.—On digesting the precipitate thrown down by ammonia
mmonia from a uranic salt in a solution of carbonate of ammonia
ill the liquid is saturated, then filtering hot, and leaving the filtrate
t separates in small transparent yellow crystals. It decomposes
at common temperatures, more quickly when heated, ultimately leav-
brick-red uranic oxide. It dissolves in 20 pts. water at 15° C., more
ontaining carbonate of ammonia. The solution, when boiled, gives
ammonia, and deposits the whole of the uranium as a yellow precipi-
according to Arfvedson, of uranic oxide with small quantities of am-
nic acid; according to Péligot, of uranate of ammonium; according
ranic hydrate containing 2 per cent. ammonia, but no carbonic acid.
. Ch. Phys. [3] v. 189; Delffs, Pogg. Ann. lv. 229.)

c Carbonate, $K^4(U^2O)^2C^3O^9$.—Obtained by dissolving in acid carbonate
precipitate thrown down from uranic salts by the neutral carbonate,

a diatomic radicle which may be supposed to exist in the uranic salts, *e.g.* uranic
= $(U^2O^2)''N^2O^6$. (See URANIUM.)

evaporating at a gentle heat, and recrystallising. It forms a bright-yellow
crust, which gives off carbonic anhydride at 300° C., and when heated to red
a red-brick mixture of uranate and carbonate of potassium. It dissolves
of water at 15° C. without decomposition, but is partially decomposed by bo
which throws down uranate of potassium. The same compound is deposi
while from a cold solution of the double carbonate, if very dilute and not contai
of carbonate of potassium. Caustic potash precipitates the whole of the
uranate of potassium, even in the presence of a large excess of carbonate of
Acids, if not added in large excess, produce the same light yellow precip
produced by carbonate of potassium in uranic salts. The double salt is
alcohol. (Ebelmen, *loc. cit.*)

Sodio-uranic Carbonate, $Na^4(U^2O^2)''C^3O^9$.—Prepared like the preceding
resembles.

Calcio-uranic Carbonate, $Ca''(U^2O^2)''C^2O^6 + 20aq.$—Found native as
amorphous rounded masses, having a distinct cleavage in one direction,
of a beautiful apple-green colour, and vitreous lustre on the fractured surfa
ness 2 to 2·5. Gives off water when gently heated and turns blackish-grey
fuse at a red heat, but turns black, and acquires an orange-red colour
Occurs, with Medjidite, near Adrianople, also at Johanngeorgenstadt,
Joachimsthal. (J. L. Smith, Ann. Ch. Pharm. lxvi. 253.)

A *calcio-uranous carbonate*, $Ca''U''C^2H^6 + 5aq.$, occurring in siskin-green sca
tions on pitch-blende at the Elias mine near Joachimsthal, has been examin
and Lindacker (Jahrb. k. k. geol. Reichsantalt, iv. 1853, 221). A carbon
nium, copper, and calcium, called *Voglite*, which may be regarded as an orth
$(U^2Cu^3Ca''H^8)C^5O^{20} + 10aq.$, occurring in the same locality in aggregation
dichroic, crystalline, pearly scales, has also been examined by Lindacker (*l*

CARBONATE OF YTTRIUM, $Y''CO^3$ (containing also erbium and terbium)
tated from yttrium-salts by carbonate of sodium, with 13 at. water in the
2 at. at the boiling heat. It is not easily decomposed by heat; dissolves
in water containing carbonic acid; decomposes ammoniacal salts and disso
liquid. Its solution in carbonate of ammonia deposits, after a time, if conc
white crystalline double salt, which does not redissolve in carbonate of
Carbonate of yttrium dissolves also, though less easily, in the carbonates o
and sodium. (Berzelius.)

CARBONATES OF ZINC.—The *neutral carbonate*, or *metacarbonate*, Zn''
native as calamine (p. 713). It is doubtful whether this anhydrous salt
tained by precipitation. According to Schindler (Gmelin's Handbook,
produced by precipitating a solution of 1 at. sulphate of zinc in 10 pts.
1 at. diacid carbonate of potassium or sodium; but, according to Berzeli
cipitate thus formed is $2Zn''CO^3.3Zn''H^2O^2$.

Hydrocarbonates. *Zinc-bloom*, which occurs in nature as an earthy i
and in reniform masses, has, according to Berzelius, the composition $5Zn''O.$
or $Zn''CO^3.Zn''O.3Zn''H^2O^2$; according to the analyses of Smithson and B
is $3Zn''O.CO^2 + 3aq.$, or $Zn''CO^3.2ZnH^2O^2 + aq.$ It is dull and opaque,
greyish, or yellowish colour, and makes a shining streak. Specific gravity
3·6. Hardness = 2 to 2·5 (Gm. vi. 15). *Aurichalcite*, or *green calamin*
found in the Altai, and at Matlock in Derbyshire, may be regarded as
$3Zn''H^2O^2$, in which the zinc is partly replaced by copper. *Buratite* (p
hydrocarbonate of zinc containing copper and calcium, perhaps a mixture.

The precipitates formed by alkaline carbonates in solutions of zinc-salts
to contain water, their constitution varying with the strength and tempera
solutions, and with the nature and proportion of the precipitant. The result
in individual cases are variously stated by different authors; those o
H. Rose (Pogg. Ann. lxxxv. 107; Ann. Ch. Pharm. lxxxiv. 210) are as fo

a. With 1 *at. Sulphate of Zinc and* 1 *at. Neutral Carbonate of Sodium.*—
solutions are cold and concentrated, the precipitate consists mainly of
$3Zn''H^2O^2 + 3aq.$, it remains unaltered at 60° C., but, after drying at 10
posed of $4Zn''CO^3.7Zn''H^2O^2 + aq.$ Very dilute cold solutions and co
boiling solutions yield a precipitate consisting mainly of $2Zn''CO^3.Z$
$Zn^3H^2C^2O^8$, combined with variable quantities of water.

b. With excess of Neutral Carbonate of Sodium.—The precipitate from col
contained, when dried at 100° C., $5Zn''CO^3.9Zn''H^2O^2$; from moderately war
$3Zn''CO^3.5Zn''H^2O^2$ (at 100°), but if very large quantities of liquid were u
sisted of $Zn''CO^3.Zn''H^2O^2$.

c. With 1 *at. Sulphate of Zinc and* 1 *at. Acid Carbonate of Sodium* (N
The precipitates contain more carbonic acid than the preceding. When they

in vacuo, a large quantity of carbonic acid escapes, and there remains the compound $2Zn''CO^3.3Zn''H^2O^2 + 2aq$.

d. With excess of Acid Carbonate of Sodium.—From cold solutions a precipitate was several times formed containing $4Zn''CO^3.5Zn''H^2O^2 + aq.$ (at 100°). A precipitation on the large scale, with rather warm solutions, yielded $2Zn''CO^3.Zn''H^2O^2$. The precipitate obtained with cold solutions, after standing for some time, had, when air-dried, but not washed, the composition $3(4Zn''CO^3.Zn''H^2O^2) + 5aq.$; after drying at 100°, it became $4Zn''CO^3.Zn''H^2O^2$.

e. With excess of Acid Carbonate of Potassium.—The precipitate not washed, but dried between filtering paper, had the composition $2Zn''CO^3 + 2H^2O$. After washing with cold water and drying in the air, it became $4Zn''CO^3 + 5aq.$; at 100° it was reduced to $4Zn''CO^3 + aq.$; and at 200° to $5Zn''CO^3 + aq$.

According to Schindler, basic salts having the composition $8Zn''O.CO^2 + 2aq.$, or $Zn''CO^3.7Zn''O.2H^2O$ and $4Zn''O.CO^2.2H^2O$, or $Zn''CO^3.3Zn''O.2H^2O$, are obtained by precipitating the corresponding sulphates of zinc with carbonate of sodium. According to Boussingault, ordinary sulphate of zinc precipitated with sesquicarbonate of sodium at ordinary temperatures, yields the salt $2Zn''O.CO^2 + 2aq.$, or $(Zn'')^2CO^4 + 2aq$. According to Schindler, hot solutions of these salts yield a precipitate of the same composition as zinc-bloom. (Gm. v. 15.)

All the hydrocarbonates of zinc give off their water and carbonic anhydride at 200° C., and are reduced to zinc-oxide, $Zn''O$. The native carbonate remains unaltered at 200°, but slowly gives off carbonic anhydride at 300°. (H. Rose.)

Ammonio-carbonate of Zinc, $NH^3.Zn''CO^3$, or *Carbonate of Zinc and Zinc-ammonium*, $\left.\begin{array}{l}2(CO)'' \\ Zn''.(N^2H^6Zn)''\end{array}\right\}O^4$.—Deposited in crystals from a solution of precipitated carbonate of zinc in a strong solution of carbonate of ammonium. (Favre, *Traité de Chimie par Pelouze et Frémy*, 2^me^ éd. iii. 47.)

Carbonate of Zinc and Potassium. $(Zn^6K^8H^2)C^{11}O^{33} + 7aq.$—Deposited in crystals from a solution of chloride of zinc mixed with sesquicarbonate of potassium. (Deville, Ann. Ch. Phys. [3] xxxii. 75.)

Carbonate of Zinc and Sodium. $(Zn^8Na^6)C^{11}O^{33} + 8aq.$—Small shining crystals, apparently tetrahedrons and octahedrons, obtained in like manner. (Deville.)

CARBONATE OF ZIRCONIUM. Solutions of zirconium-salts, treated with excess of alkaline carbonate, yield a precipitate soluble in acid carbonates of alkali-metal, and containing, according to Hermann, 76·6 per cent. zirconia and 20·39 per cent. water, agreeing with the formula $2Zr^2O^3.CO^2 + 6aq$. According to Klaproth, however, it contains 51·5 per cent., and, according to Vauquelin, 55·5 per cent. zirconia.

CARBONIC ACID and **ANHYDRIDE.** See CARBON, OXIDES OF (p 770).

CARBONIC ETHERS. *Carbonates of Alcohol-radicles.*—These compounds are metacarbonates, M^2CO^3, in which one or both atoms of base are alcohol-radicles. Those which contain 2 at. of alcohol-radicle, the *neutral carbonic ethers*, are obtained: 1. By the action of carbonate of silver on the iodides of the alcohol-radicles.—2. By the action of potassium or sodium on the corresponding oxalates. This reaction is attended with evolution of carbonic oxide, and probably takes place in the manner represented by the following equation:

$$\underset{\text{Oxalate of ethyl.}}{2(C^2H^5)^2C^2O^4} + K^2 = \underset{\text{Carbonate of ethyl.}}{(C^2H^5)^2CO^3} + \underset{\text{Ethylate of potassium.}}{2C^2H^5KO} + 3CO.$$

3. By the action of water on the chlorocarbonates of the alcohol-radicles (produced by passing oxychloride of carbon into the alcohols), and by the dry distillation of these same products. In presence of water, the action is such as is represented by the equation,

$$\underset{\text{Chlorocarbonate of amyl.}}{2\left(\begin{array}{l}CO'' \\ C^5H^{11}\end{array}\left\}\begin{array}{l}O \\ Cl\end{array}\right.\right)} + H^2O = \underset{\text{Carbonate of amyl.}}{(C^5H^{11})^2CO^3} + CO^2 + 2HCl.$$

The decomposition of the chlorocarbonates by dry distillation is more complicated, a considerable quantity of charred matter remaining behind; but the principal reaction is doubtless the splitting up of 2 at. of the chlorocarbonate into a carbonic ether and oxychloride of carbon, *e. g.*:

$$2(CClO^2.C^5H^{11}) = (C^5H^{11})^2CO^3 + COCl^2.$$

The neutral carbonic ethers are ethereal oily liquids, insoluble in water, soluble in alcohol and ether. They are decomposed by alcoholic potash, yielding carbonate of potassium and the corresponding alcohols. Two volumes of the vapour of each of these ethers contain two volumes of alcohol-radicle, a fact which tends to establish the dibasicity of carbonic acid. (See ACIDS, p. 46.)

The *acid carbonic ethers* (carbonates of alcohol-radicles and hydrogen)
known, but some of their salts have been prepared.

Carbonate of Allyl. $C^7H^{10}O^3 = (C^3H^5)^2CO^3$.—Obtained by the a
iodide of allyl on carbonate of silver (Zeise, Ann. Ch. Pharm. xcvi. 361), or c
sium or sodium on oxalate of allyl (Cahours and Hofmann, Phil. Trans.
555). It is an ethereal liquid lighter than water. The alcoholic solution treat
hydrate of barium, yields carbonate of barium and allyl-alcohol.

Carbonate of Amyl. $C^{11}H^{22}O^3 = (C^5H^{11})^2CO^3$.—Prepared: 1. By sa
amylic alcohol with oxychloride of carbon, decomposing the product with wate
ing it with oxide of lead to remove chlorine, drying over chloride of calcium,
tifying (Medlock, Chem. Soc. Qu. J. i. 368).—2. By decomposing oxalate
with potassium or sodium. The action begins immediately, but heat is requ
complete it. By distillation, a yellow liquid is obtained, which begins to boil at
yielding amylic alcohol; afterwards carbonate of amyl passes over at 225°, the
amounting to about three-fourths of the original distillate. The residue co
strong-smelling viscid matter. (Bruce, Chem. Soc. Qu. J. v. 132.)

Carbonate of amyl is a colourless liquid, having an agreeable odour, and
gravity = 0·9144; it boils at 224°—225° C.

Carbonate of Ethyl. *Carbonic Ether.* $C^5H^{10}O^3 = (C^2H^5)^2CO^3$.—Th
is prepared: 1. By the action of potassium or sodium on oxalate of ethyl, the m
being heated in a retort to 130° C., and fresh potassium or sodium added, as long
bonic oxide continues to escape. On cooling the residue and treating it wit
carbonate of ethyl rises to the surface: it is dried with chloride of calcium, and
over a small quantity of sodium, then heated alone till the boiling point
stationary, the portion which afterwards passes over being collected apart (E
Ann. Ch. Pharm. xix. 17).—2. By distilling a mixture of ethyl-carbonate and
sulphate of potassium. (Chancel, Compt. rend. xxxi. 521.)

$$C^2H^5.K.CO^3 + C^2H^5.K.SO^4 = K^2SO^4 + (C^2H^5)^2CO^3.$$

Carbonate of ethyl is a colourless limpid oil, having a sweet ethereal odo
burning taste. Specific gravity = 0·975 at 19° C. Boils at 125°, and volatilises
decomposition. Vapour-density = 4·243 (Ettling); 4·09 (Cahours); by cal
for a condensation to 2 vol. it is $\frac{60 + 10 + 48}{2} \times 0{\cdot}0693 = 4{\cdot}089$. It is infla
and burns with a blue flame. It is insoluble in water, but dissolves easily in
and ether. With alcoholic potash, it yields alcohol and carbonate of potassium.
with sodium, it gives off carbonic oxide, and forms ethylate of sodium, togeth
carbonate (?) (Löwig, Pogg. Ann. l. 122). The reaction is perhaps: $C^5H^{10}O^3$
$2C^2H^5NaO + CO$ (Gm. ix. 393). Chlorine decomposes carbonate of ethyl, abs
hydrogen, and forming the two following substitution-products:

Tetrachlorocarbonic Ether, $C^5H^6Cl^4O^3$, commonly called *Bichlorocarbon*
—Obtained by passing chlorine through carbonate of ethyl in diffused dayligh
ing the liquid to 70°—80° C. in the latter part of the process, and expelling th
of chlorine by a stream of carbonic anhydride. It is a colourless liquid havin
charine odour, much heavier than water, and insoluble therein; soluble in alco
is decomposed by dry distillation. (Cahours, Ann. Ch. Phys. [3] ix. 201.)

Perchlorocarbonic ether, $C^5Cl^{10}O^3$. (Cahours, *loc. cit.*; Malaguti, A
Phys. [3] xvi. 80.)—Produced by the continued action of chlorine on the pr
compound in direct sunshine. The resulting crystalline mass must be pur
pressing it between folds of bibulous paper, washing it rapidly with small quan
ether, again pressing, and leaving it for some days in a dry vacuum. It ca
purified by crystallisation from alcohol or ether.

It is a white mass, composed of small needles, and having a faint odour
between 86 and 88° C., and solidifies between 65° and 63°. At a higher tem
it partly distils unaltered, and is partly resolved into carbonic anhydride, ch
trichloracetyl, and trichloride of carbon:

$$C^5Cl^{10}O^3 = CO^2 + C^2Cl^3O.Cl + C^2Cl^6.$$

When dissolved in alcohol, it changes to an oil which is a mixture of carbon
trichloracetate of ethyl, a large quantity of hydrochloric acid being produced
same time:

$$C^5Cl^{10}O^3 + 4C^2H^6O = (C^2H^5)^2CO^3 + 2(C^2H^5.C^2Cl^3O^2) + 4HCl.$$

Heated with potash-ley, it yields formate, chloride and acid carbonate of po
together with hydrochloric acid:

$$C^5Cl^{10}O^3 + 10KHO = 2CHKO^2 + 5KCl + 5HCl + 3KHCO^3.$$

With gaseous ammonia, it forms sal-ammoniac, chlocarbethamide (trichlorac rhardt, *Traité*, i. 16·6), and an unknown substance, which crystallises Malaguti). When thrown into aqueous ammonia, it makes a hissing t iron in water, and forms trichloracetamide, together with carbonate, oride of ammonium, and probably also other ammoniacal salts. (Mala-

OF ETHYL AND POTASSIUM. *Ethyl-carbonate* or *Carbovinate* $H^5KO^3 = C^2H^5.K.CO^3$. (Dumas and Péligot, Ann. Ch. Phys. [2] ined by passing carbonic anhydride into a solution of perfectly dry ssium in absolute alcohol, the liquid being carefully kept cool, which by introducing from time to time small portions of anhydrous ether. posit then forms, consisting of ethyl-carbonate of potassium, together d acid carbonate. The ethyl-carbonate is formed as represented by

$$C^2H^6O + KHO + CO^2 = C^2H^5.K.CO^3 + H^2O;$$

ate results from the action of the water thus formed on a portion of the and the neutral carbonate from that of the excess of potash on the To separate the ethyl-carbonate, the mass is treated with an equal , which dissolves the excess of free potash, and leaves the two other d: the ethyl-carbonate is then dissolved out by alcohol, precipitated by ly dried. It might doubtless be more easily prepared from anhydrous ssium, C^2H^5KO.

ate of potassium is a white nacreous salt, which burns with flame on eaving a carbonaceous residue, and yields by distillation an inflam- all quantity of ethereal liquid, and a residue of carbonate mixed with r transforms it into alcohol and acid carbonate of potassium:

$$C^2H^5.K.CO^3 + H^2O = C^2H^5.H.O + KHCO^3.$$

c acid, $C^2H^5.H.CO^3$, has not yet been obtained; neither has *Carbonate* $)^2CO^3$, nor *Methyl-oarbonic acid*, $CH^3.H.CO^3$.

OF METHYL AND BARIUM. *Methyl-carbonate of Barium.* $)^2$ (Dumas and Péligot, *loc. cit.*).—A solution of anhydrous baryta ethylic alcohol, subjected to the action of carbonic anhydride, yields a e, which after washing with methylic alcohol, consists entirely of e of barium:

$$.H.O) + 2Ba''O + 2CO^2 = (CH^3)^2.Ba''(CO^3)^2 + Ba''H^2O^2.$$

soluble in methylic or ethylic alcohol, but dissolves easily in cold water. n however becomes turbid, depositing a considerable quantity of car- n and giving off carbonic anhydride. The action is greatly assisted , and at the boiling-point it is instantaneous.

OF METHYL AND ETHYL. $C^4H^8O^3 = CH^3.C^2H^5.CO^3$ (Chancel, xi. 521).—Obtained by distilling a mixture of methyl-carbonate and f potassium:

$$CH^3.K.CO^3 + C^2H^5.K.SO^4 = K^2SO^4 + CH^3.C^2H^5.CO^3.$$

OF PHENYL AND HYDROGEN. $C^6H^5.H.CO^3$.—Salicylic acid (*q. v.*) d as constituted in this manner. When subjected to dry distillation, carbonic anhydride and hydrate of phenyl.

OF TETRYL. *Carbonate of Butyl.* $C^9H^{18}O^3 = (C^4H^9)^2.CO^3$.—Pro- the action of iodide of tetryl on carbonate of silver, the materials each) being enclosed together in a sealed flask, and heated for two days n,—distilling the product, collecting apart that which passes over above tifying (Ph. de Clermont, Ann. Ch. Phys. [3] xliv. 336).—2. By the le of cyanogen, either gaseous or liquid, on tetrylic alcohol, in presence mann, *ibid.* xliv. 340):

$$(C^4H^9.H.O) + CNCl + H^2O = (C^4H^9)^2CO^3 + NH^4Cl.$$

limpid liquid, lighter than water, and having an agreeable odour like e of ethyl. It boils at 190° C. Aqueous ammonia converts it into and carbonate of tetryl.

TROTOLUYLIC ACID, also called *Nitrodracylic acid.*—An acid white slender needles, obtained by treating toluene with excess of strong lenard and Boudault (Compt. rend. xix. 505), who discovered it, he formula $C^8H^6NO^4$; it is more probably isomeric with nitrotoluylic or perhaps, as suggested by List (Gm. xiii. 24), the product was zoic acid containing nitrostyrol.

CARBONYL. CO.—The diatomic radicle of the carbonates, carbamat mides, &c.

CARBOPYRROLIC ACID. $C^5H^5NO^2 = \left.\begin{matrix} NH^2(C^5H^2O)'' \\ H \end{matrix}\right\} O.$ (Sch Ann. Ch. Pharm. cxiv. 63.)—An amic acid, obtained by heating Malaguti's p mide, $C^5H^6N^2O$ (*q. v.*), which Schwanert regards as carbopyrrolamide, $N^2.H^4$.(with baryta-water in sealed tubes. Ammonia is then formed, together with ca late of barium, $C^{10}H^8Ba''N^2O^4$, which crystallises in nacreous laminæ, and is n posed by heating with potash-ley. The concentrated aqueous solution tre hydrochloric acid, deposits carbopyrrolic acid as a white crystalline precipit *lead-salt*, $C^{10}H^8Pb''N^2O^4$, forms sparingly soluble nacreous laminæ.

When the aqueous solution of carbopyrrolic acid is heated to 60° C. or abov C^4H^5N, separates from it as a brown flocculent substance.

CARBOSTYRIL. $C^9H^7NO = N(C^8H^7)(CO)''$.—Produced by the acti phide of ammonium on nitrocinnamic acid. Probably an acid, $C^9H^9NO^2$, is duced and afterwards converted into carbostyril by loss of 1 at. water, thus:

$$\underset{\text{Nitrocinnamic acid.}}{C^9H^7(NO^2)O^2} + 2H^2S = C^9H^9NO^2 + 2H^2O + S^2$$

$$\text{and}\quad C^9H^9NO^2 - H^2O = \underset{\text{Carbostyril.}}{C^9H^7NO.}$$

The liquid is supersaturated with hydrochloric acid, filtered, and evaporated. deposits crystals of carbostyril, coloured brown by a resin, which may be re recrystallising the product several times from boiling water.

Carbostyril forms beautiful colourless silky needles, moderately soluble i water, easily in alcohol and ether; melts when heated, and at a higher te sublimes in shining needles; dissolves in hydrochloric acid, also in boilin not in ammonia or in sulphuric acid. Heated with solid potash, it yields an appears to be a peculiar alkaloïd (C^8H^7N?) Boiled with oxide of silver, i compound insoluble in boiling water, from which it is separated by acids in i state. (Chiozza, Compt. rend. xxxiv. 598.)

CARBOTHIACETONINE. $C^{10}H^{18}N^2S^2$.—The sulphydrate of this b posited in yellow crystals on mixing acetone with ammonia and sulphide of

$$3C^3H^6O + CS^2 + 2NH^3 = C^{10}H^{18}N^2S^2 + 3H^2O.$$

(Städeler, Pharm. Centr. 1853, p. 433; see also ACETONE, p. 28.)

CARBOTHIALDINE. $C^5H^{10}N^2S^2$.—A colourless crystalline body, pro adding sulphide of carbon to an alcoholic solution of aldehyde-ammonia. luble in cold water and in ether, sparingly soluble in cold alcohol, easily alcohol. Dissolves in hydrochloric acid, and is reprecipitated by ammoni with excess of hydrochloric acid, it is resolved into sulphide of carbon, sal- and aldehyde. On adding oxalic acid and then ether to the alcoholic soluti bothialdine, crystals of oxalate of ammonium are formed. The alcoholi forms, with *nitrate of silver*, a greenish-black precipitate, which gradually ch sulphide of silver; with *mercuric chloride* it forms a thick white curdy preci with *copper-salts* a green precipitate. (Redtenbacher and Liebig, Pharm. lxv. 43.)

CARBOTRIAMINE. $N^3\left\{\begin{matrix} \overset{''''}{C} \\ H^5 \end{matrix}\right.$—Guanidine, a base obtained by the oxidising agents on guanine, may be viewed as a triple molecule of ammon in which 4 at. H are replaced by the tetratomic radicle carbon. Several su derivatives of carbotriamine are also known, viz.:

Carbomethyltriamine. $N^3.\overset{''''}{C}.(CH^3)H^4$.—This constitution may be ascrib thyluramine, a base resulting from the action of oxidising agents on creatin

Carbotriethyltriamine. $N^3.\overset{''''}{C}.(C^2H^5)^3H^2$.—Produced by heating cyanurat with ethylate of sodium. (Hofmann, Proc. Roy. Soc. xi. 282.)

Carbodiphenyltriamine. $N^3.\overset{''''}{C}.(C^6H^5)^2.H^3$.—This is the composition of me

Carbotriphenyltriamine. $N^3.\overset{''''}{C}.(C^6H^5)^3.H^2$.—This base is produced by the tetrachloride of carbon on phenylamine (p. 765).

All these bases may likewise be regarded as diamines containing 1 at. cy place of 1 at. hydrogen; thus, carbotriamine = cyan-diamine = $N^2(CN)$. ETHYL-, METHYL-, and PHENYL-DIAMINES and TRIAMINES.)

CARBOVINIC ACID. Syn. with CARBONATE OF ETHYL and HYDRO CARBONIC ETHERS, p. 801.)

OMETHYLIDE. Carbonate of Ethyl and Methyl (p. 801).

E. A gem highly prized by the ancients, probably the almandin

C ACID. Syn. with Allophanic Acid.

ULPHATE OF. $C^2H^4S^2O^6$.—Syn. with Ethionic Anhydride.

IE AMARA. The dried herb of this plant contains an azotised organic acid, either identical with or very similar to the myronic acid l seed, in combination with an organic (probably basic) compound. id, either free or in combination with bases, develops, under the in-vn, but not under that of the emulsion of bitter almonds, an acrid much like oil of horse-radish or scurvy grass. The decided bitterness of pungency of the fresh herb appear to be due to the absence of ome analogous compound capable of developing the pungent oil. rb. pr. Pharm. xviii. 89.)

M OIL. An essential oil extracted by distillation from the seeds of ardamom, especially *Alpinia cardamomum* and *Amomum repens*. It is nd has a burning taste. Specific gravity, 0·945. Soluble in ether, also in acetic acid and caustic potash. It detonates with iodine, and trong nitric acid. The oil amounts to 4·9 per cent. of the seed-kernels s.

ted from old cardamom oil were found by Dumas and Peligot [2] lvii. 334) to have the formula of a hydrate of camphene,

contains a fixed non-drying oil, which has a rancid bitter taste, and ing with potash.

An oily liquid contained, together with anacardic acid (p. 209), in the shew-nut (*Anacardium* or *Cassuvium occidentale*). To obtain, it the sted with ether, the ether distilled off, the residue washed with water then dissolved in 15 to 20 pts. of alcohol, and digested with recently ate of lead, which takes up the anacardic acid, while the cardol re-. The greater part of the alcohol is removed from the filtered liquid ater added to the remaining liquid till it becomes turbid, and after-l subacetate of lead till it is decolorised. Lastly, the lead is precipi-c acid.

low oily liquid, insoluble in water, very soluble in alcohol and ether; neutral to litmus. It is not volatile, but decomposes when heated. in strongly. According to Städeler, it contains 60 per cent. carbon drogen, whence he deduces the formula $C^{42}H^{31}O^4$; it should perhaps

tates basic, but not neutral acetate of lead. Strong sulphuric acid red colour. Nitric acid appears to form with it under certain cir-ame products as with anacardic acid. Strong potash-ley colours it ately dissolves it; and the solution, in contact with the air, acquires , and then forms red or violet precipitates with most metallic salts. Ch. Pharm. lxiii. 137.)

ne ashes of *Carex remota* and *C. acuta* have been examined by E. r. Chem. lxix. 149.)

ts contained in 100 pts.:

	Water.	Organic matter.	Ash.
remota	52·75	45·18	2·07
acuta	69·60	29·28	1·12

ned:

	KCl	NaCl	K^2O	Na^2O	CaO	MgO
. .	2·81	10·23	23·52	0·72	7·86	9·22
. .	4·90	7·28	37·94	0·35	7·90	7·36
	Fe^2O^3	MnO	P^2O^5	SO^3	CO^2	SiO^2
. .	2·23	1·45	4·95	1·93	4·75	30·33
. .	1·39	2·02	7·66	1·36	4·86	16·98

of soluble and insoluble constituents of the ash were as follows:—

Soluble in water.	Soluble in nitric acid.	Insoluble.
49·15	29·45	21·40
57·56	31·59	10·85

CARICA PAPAYA. *Papaw Tree.*—Every part of the papaw tree, e ripe fruit, affords a milky juice, which is used in the Mauritius as an effectua for the tape-worm. In Europe, however, whither it has been sent in the state, it has not answered. The milky juice is said to make meat washed i tender, and the leaves and fruit are said to have the same effect upon the fle hogs and poultry which are fed with them; the flesh, however, soon becom The juice yields a substance resembling the flesh or fibre of animals.

CARIES. See BONE (p. 623).

CARINTHIN. A sub-species of augite. Colour black. Occurs massive minated. Internally splendent. Resino-vitreous. Distinct cleavage of 124° 34'. conchoïdal. Greenish-black variety: translucent on the edges, velvet-blac Occurs on the Saualp in Carinthia, in a bed of primitive rock, associated wi kyanite, garnet, and zoisite. (*Jameson's Mineralogy.*)

Dana (ii. 172) enumerates it as a variety of hornblende.

CARMIDINE. An organic base produced by passing lutidine over red- Its composition has not been ascertained. It produces a fine red colour w wood and hydrochloric acid, and pale green with bleaching powder; hence bably a mixture of pyrrhol and vertidine. (Gr. Williams, Chem. So vii. 97.)

CARMINAPHTHA. $C^{18}H^{8}O^{3}$ (?)—A red colouring matter obtained b naphthalene with a solution of acid chromate of potassium, and adding sul hydrochloric acid. It is dissolved by alkalis and precipitated in its original acids. (Laurent, Rev. scient. xiv. 560.)

CARMINDIN. A product which Laurent obtained by the action of am dibromisatin. (See ISATIN.)

CARMINE. CARMINIC ACID. (Pelletier and Caventou, Phys. [2] viii. 250, li. 194; Warren de la Rue, Ann. Ch. Pharm. lxiv. 1, 2 iii. 750.)—The colouring matter of cochineal (*Coccus cacti*). To separate it, is exhausted with boiling water; the extract is precipitated by subacetat slightly acidulated, care being taken not to add the lead-solution in exc precipitate is washed with distilled water till the wash-water no longer gives pitate with a solution of mercuric chloride, then decomposed by sulphuretted h the filtrate is evaporated to a syrupy consistence and dried over the water-b the dark purple product thus obtained is treated with alcohol, which extracts minic acid.

This acid forms a purple mass, fusible and soluble in all proportions in wat alcohol. Sulphuric and hydrochloric acid dissolve it without alteration. It heat of 136° C. without decomposition. It is very hygroscopic. Its solution precipitates with the alkaline earths, also with the acetates of lead, zinc, co silver.

According to De la Rue's analysis, carminic acid contains 54·1 per cent. ca 4·6 hydrogen, agreeing nearly with the formula $C^{14}H^{14}O^{8}$.

Schützenberger (Ann. Ch. Phys. [3] liv. 52) regards De la Rue's carm as a mixture, and assigns to pure carminic acid the formula $C^{9}H^{8}O^{5}$; he st that it is mixed in cochineal with an oxycarminic acid, $C^{9}H^{8}O^{7}$, and perhaps other acids of intermediate composition. These statements do not appear, to be borne out by the results of his analyses.

Carminic acid is decomposed by chlorine and bromine. The bromine-com yellow and soluble in alcohol.

Carminic acid treated with nitric acid yields *nitrococcusic acid*; a compoun is isomeric with trinitranisic acid, and crystallises in yellow rhomboïdal table in cold but more soluble in hot water; soluble also in alcohol and ether. All are soluble in water.

The mother-liquor of the preparation of carminic acid contains a crystall stance, insoluble in alcohol and ether, soluble in ammonia, and identical with (Warren de la Rue.)

The colouring principle of cochineal (carmine) was previously obtained in a state by Pelletier and Caventou (Ann. Ch. Phys. viii. 250), by treating the with ether to extract the fatty matter, and digesting the residue in alcohol.

The fine red pigment known in commerce as carmine, is prepared by t solution of cochineal with cream of tartar, alum, or acid oxalate of potassiu fatty and albuminous matters then coagulate and carry down the colourin with them.

By treating a solution of cochineal with an alkaline carbonate and alum, a c of the colouring matter with alumina is obtained, known by the name of *carm*

, the coarser sediment deposited from a decoction of cochineal, after
s have been separated by decantation, is generally used. For cheaper
Brazil wood is sometimes mixed with the cochineal.
ours are used for dying wool and silk crimson or scarlet; but the
es are remarkable more for brilliancy than for durability, and are easily
r or alkalis. The mordants used are alum, cream of tartar, and tin-
Dictionary of Arts, Manufactures and Mines, i. 616.)

TE, or *Carmine-spar*.—A mineral, probably consisting of anhydrous
and iron, from Hornhausen in Saxony, where it occurs, with Beudan-
nd brown iron ore. It occurs in clusters of fine needles, and in sphe-
h columnar structure, cleaving parallel to the faces of a rhombic prism.
. Lustre vitreous, but pearly on the cleavage faces. Colour carmine
wder reddish-yellow. Translucent. Brittle. Before the blowpipe it
ns of arsenic, lead, and iron. (Dana, ii. 410.)

LLIC ACID. An acid obtained by Muspratt and Danson (Phil.
), by the action of nitric acid on the aqueous extract of cloves. It
he concentrated solution in yellow micaceous scales; and by precipi-
ate of lead, decomposition of the lead-precipitate with sulphuretted
vaporation, it may be obtained in white crystals. It is insoluble in
and cold water, soluble in hot water, ammonia, and potash. When
a yellow oil and emits an odour of burnt sugar. Strong sulphuric
t upon it in the cold, but carbonises it when heated. A moderately
ution of the acid precipitates the salts of the alkaline earths, forming
latinous mass. With copper-salts it forms a green, with silver and
hite, and with ferric salts a yellow precipitate, all of flocculent cha-
tt and Danson assign to the barium and lead-salts of this acid, the
, $C^{24}H^{30}MO^{23}$.

TE. $KCl.Mg''Cl^2.6H^2O$.—A salt which sometimes separates in coarse-
often coloured by oxide of iron, from the mother-liquor of rock-salt,
rine-springs; it may also be obtained by careful evaporation of the
sea-water. (Jahresber. f. Chem. 1856, p. 884; 1858, p. 739.)

A WAX. A wax which coats the leaves of the *Corypha cerifera*, a
Brazil, and is obtained by drying the leaves and melting the coating,
in scales. It forms hard, brittle lumps of yellowish-white colour, in-
and has an odour of melilot, but no taste. It melts at 97° C., or accord-
Ann. Ch. Phys. [3] xiii. 438) at 83·5°. According to Brande (Phil.
261), it is insoluble in cold, sparingly soluble in hot alcohol, forming a
. Similarly with ether. With fixed oils it mixes in all proportions.
tash it forms a pale rose-coloured mass without actually saponifying.
rts the wax into a yellow friable mass. Chlorine bleaches it. In
behaves like beeswax. According to Lewy, it contains 80·3 per cent.
hydrogen. (Handw. d. Chem. 2te Aufl. ii. [2] 807.)

A variety of lithomarge from Rochlitz. (Breithaupt.)

AN. A subspecies of chalcedony, of white, yellow, brown, and red
a conchoïdal fracture. Specific gravity 2·6. Semitransparent, with
. The finest specimens come from Cambay and Surat in India. It is
r strata, thirty feet below the surface, in nodules of a blackish-olive
nto grey. These, after two years' exposure to the sun, are boiled for
ereby acquire the lively colours for which they are prized in jewellery.
er than common chalcedony. It consists mainly of silica (about 94
alumina, and a small quantity of sesquioxide of iron. According to
ubry, the colour proceeds, not from oxide of iron, but from an organic
, however, is denied by Heintz. (Pogg. Ann. lx. 519.)

IN. A mineral containing organic matter, found in a coal-mine in
It has the aspect of honey-stone; colour, honey-yellow to wine-yellow:
he edges; has a faint unctuous lustre; very brittle. Specific gravity
s 2·5. It is decomposed by hydrochloric acid. It contains about 15·10
47·25 alumina, 29·52 silica, and 1·33 carbon. The water is not com-
below 290° C., at which temperature the organic matter begins to de-
organic matter appears to be allied to humic acid. (Sonnenshein,
268.)

$C^{18}H^{24}O$.—The colouring matter of the carrot (*Daucus Carota*). It
d by Wackenroder in 1831 (Geiger's Mag. xxxiii. 144), afterwards
eise (J. pr. Chem. xl. 297), and recently with greater exactness by
nn. Ch. Pharm. cxvii. 200).

Carrots also contain a colourless substance, hydrocarotin, $C^{18}H^{30}O$, c
6 at. H more than carotin; and as they are colourless in the early stage
growth, Husemann considers it probable that they at first contain only hyd
which gradually changes to red carotin by oxidation.

Preparation.—The expressed juice of bruised carrots is precipitated with
acid, to which a small quantity of tincture of galls is added; the half-dried co
repeatedly boiled with five or six times its volume of 80 per cent. alcohol, whic
the hydrocarotin; the residue, after drying at a gentle heat, is exhausted with
of carbon; and the filtrate is mixed with an equal volume of absolute alco
solution, when left to itself, deposits the carotin in crystals of the dimetric syste
while in the liquid, exhibit a golden-green lustre by reflected light; if, how
sulphide of carbon was mixed with much alcohol, or if the solution was too m
centrated, the crystals are microscopic, and of a ruby-colour. The crystals ar
on a water-bath funnel with boiling 80 per cent. alcohol, afterwards with ab
cohol, till the wash-liquid exhibits only a faint yellow colour, and when evap
a watch-glass, leaves small octahedral crystals.

The pure carotin which remains, exhibits, after drying in the air at mean
ture, a red-brown colour with velvet lustre, becoming bright red when dried
It smells like Florentine violet-root, especially when heated. It is rather hea
water; dissolves sparingly in alcohol, ether, and chloroform, easily in sulphid
bon, benzene, and volatile oils; fixed oils dissolve it slowly, with red colou
comes soft at 126° C., and melts at 168° to a thick dark red liquid.

Carotin forms at low temperatures a colourless crystalline hydrate, whic
obtained by placing a concentrated solution of carotin in sulphide of carbon (
drous) in a watch-glass, over a freezing mixture producing a temperature of −
then separates as a white efflorescence made up of small needles; but as soo
taken out of the freezing mixture, it gives up its water, and is converted into re
The same phenomenon is exhibited by a solution of carotin in benzene, excep
the hydrate is then slightly yellow. Another hydrate is sometimes formed
to a dilute solution of carotin in sulphide of carbon, so much absolute alcohol
turbidity at first produced shall disappear, at least on heating the liquid. It
in thin, iridescent, six-sided laminæ, and appears to be more stable than the f
tioned hydrate. The composition of these hydrates has not been determined.

Carotin is very unstable; during the evaporation of its solution, it often sep
a light yellow amorphous modification, which is but sparingly soluble in su
carbon. The red crystals gradually become colourless from without inwar
exposed to daylight, and more quickly in sunshine; the new substance thus
inodorous, dissolves readily in alcohol or ether, but with difficulty in sulphide
or benzene, and separates from these solutions in the amorphous state.
change takes place when carotin is exposed for a long time to a heat o
Whether the new substance thus formed has the same composition as caroti
yet made out. Carotin heated to 250° C. forms a mobile liquid, which on coo
difies to a soft yellowish-red mass. At higher temperatures, it carbonises and
empyreumatic vapours.

Fuming nitric acid dissolves carotin with yellow colour, and water separ
the solution a yellow nitro-compound. *Strong sulphuric acid* dissolves car
purple colour; and on carefully adding water, the colour disappears, and a s
modified carotin separates in dark green flocks, which, like carotin altered by
coloured brown by sulphuric acid.—*Sulphurous anhydride* changes the colour o
to dark indigo, but does not alter it further; the blue substance crystallises f
zene in red cubes, and is also converted into red carotin by boiling with potas

Dry chlorine gas converts carotin into tetrachloro-carotin, a white s
soluble in ether and in sulphide of carbon, becoming soft and dark-red at
melting at 120°. Another substitution-product containing less chlorine app
to be formed.

Bromine and *iodine* likewise decompose carotin, forming substitution-produc
are more fusible than carotin itself.

Carotin is not decomposed by dilute acids, by hydrochloric acid gas, sulp
hydrogen, sulphide of ammonium, or by alkalis, either in aqueous or in alcoho
tions. Solutions of carotin are not precipitated by metallic salts; the alcoholic
is coloured greenish by ferric chloride.

A substance having the same colour and composition as carotin, is obtained
ing tribromhydrocarotin, $C^{18}H^{27}Br^{3}O$, with potash; but the identity of the two
yet been completely established. (See HYDROCAROTIN.)

CARPHOLITE. A silicate of manganese, aluminium, and iron, fou
Schlackenwald in Bohemia, in radiated and stellated tufts, sometimes also in
prisms of 111° 27′, and 68° 33′, with the lateral edges truncated. Specific gr

ness = 5 to 5·5. It is opaque, with straw-yellow or wax-yellow colour ne, from κάρφος, straw), and vitreous lustre. Its analysis gives—

O^3	Mn^2O^3	Fe^2O^3	$Ca''O$	H^2O	F		
7	18·33	6·27	—	11·36	—	= 99·961	(Steinmann).
57	19·16	2·54	0·27	10·78	1·40	= 98·97	(Stromeyer).
74	20·76	9·87	2·56	11·35	—	= 100·43	(Hauer).

mula $2R^2O^3.3SiO^2 + 3aq.$, the sesquioxides of aluminium, manganese, and posed to replace each other isomorphously.

the sesquioxides to protoxides (substituting $r = \frac{2}{3}R$), the formula be- an orthosilicate, $2r''O.SiO^2 + aq. = r^2SiO^4 + aq.$ According to Kobell, e and iron are in the state of protoxides, and the formula is $(Mn''O.Al^2O^3)$). (*Rammelsberg's Mineralchemie*, p. 587.)

SIDERITE. A hydrated phosphate of iron, containing small quantities and zinc, occurring in reniform masses and incrustations of straw-yellow sinous lustre. Specific gravity 2·5; hardness 4 to 4·5. It is found in a slate, and was first distinguished by Breithaupt, among some specimens r. (Dana, ii. 431.)

STILBITE. A straw-yellow variety of Thomsonite, from Bernfiord,

ALSAMUM. A commercial name of the volatile oil obtained from pi- uit of *Myrtus pimenta*. It is yellowish, heavier than water, and smells

ITE. (W. L. Faber, Sill. Am. J. (2) xiii. 418; Smith and Brush, ; Genth, *ibid.* xxiii. 115.)—A sulphide of cobalt and copper, from Finks- County, Maryland, U. S. Forms homogeneous, very friable masses, et cleavage; tin-white to steel-grey colour; metallic lustre; iron-black en fracture, approaching to the conchoïdal. Hardness 5·5. Specific The mineral has not been found in distinct crystals, but appears to belong system.

As	Cu	Co	Ni	Fe	Quartz		
·82	32·99	28·50	1·50	5·31	2·13	= 99·30	(Faber).
–	18·15	37·70	1·54	1·26	—	= 100·08	(Smith and Brush).
–	17·55	38·70	1·70	0·46	0·97	= 100·19	(Genth).

ces from his analysis (after deducting the nickel, arsenic, and iron, toge- 38 per cent. sulphur required to form copper-nickel and magnetic pyrites), $Co''S.(Cu^2)''S$ or $Co''(Cu^2)''S^2$. Smith and Brush regard the mineral as (Co^3S^4), in which part of the cobalt is replaced by copper.

HEEN MOSS. See Caragheen Moss (p. 747).

. *Daucus Carota.*—The ashes of the root, leaves, and seed of the carrot lysed by Way and Ogston (Jahresber. f. Chem. 1849, Table E to page), Table B to p. 660) with the following percentage results:

	White Belgian		Long red Surrey (on poor sandy soil)		
	Root.	Leaves.	Root.	Leaves.	Seed.
	21·40—41·97	6·55— 7·53	43·78	17·10	16·21
	8·18—17·53	9·46—12·76	12·11	4·85	1·23
	6·08—11·89	29·50—34·96	5·64	24·04	32·96
	3·20— 5·89	2·50— 3·23	2·29	0·89	5·70
	0·59— 1·66	0·90— 4·06	0·51	3·43	0·84
dride	4·59— 9·49	5·47— 6·68	4·26	5·08	4·80
	0·76— 1·92	1·83— 7·39	1·11	11·61	4·50
	15·15—19·11	14·92—22·25	18·00	23·15	15·13
	7·86— 9·17	1·12— 2·55	12·31	6·21	13·38
ium	4·91— 7·65	8·77—15·11	trace	3·62	5·24
			99·96	99·98	99·99
f dry substance	5·12— 8·80	15·80—21·30	8·44	10·08	4·30
fresh ,,	0·77— 1·06	2·85— 5·32	0·47	8·73	3·30
pts. of air-dried substance			86·40	80·00	13·00
nt. in dry substance			—	0·88	3·05

, OIL OF. The root of the carrot contains a very small quantity (0·0114) volatile oil, of specific gravity 0·8863 at 12° C., which may be obtained by distilling the fresh roots with water. It has a very strong pungent taste and sm dissolves sparingly in water, freely in alcohol and in ether. (Wackenroder, I Pharm. xxxiii. 145.)

CARTHAMIN. The colouring principle of safflower (*Carthamus tinctorius*), examined by Chevreul, afterwards more fully by Schlieper (Ann. Ch. Pha lviii. 362.)

The flowers of *Carthamus tinctorius* contain two coloured principles, one yel soluble in water, and of no use in dyeing, the other red, soluble in alkalis and pr pitable by acids from its alkaline solutions: this is *carthamin*. To prepare it, saffl is first washed repeatedly with water, to free it from the yellow substance, then tre with solution of carbonate of sodium; the liquid is saturated with acetic acid; pieces of cotton are immersed in it, on which the carthamin is deposited. A twenty-four hours, the cotton is removed and treated with solution of carbonat sodium, which redissolves the colouring matter; the solution is mixed with citric whereby the carthamin is precipitated in red flocks; and, lastly, these flocks are solved in alcohol. The solution evaporated in vacuo yields the carthamin in the of a powder, having a deep red colour with greenish iridescence. It is sparingly sol in water, insoluble in ether, but easily soluble in alcohol, yielding a fine pu solution.

According to Schlieper, carthamin contains 56·9 per cent. carbon and 5·6 hydro agreeing with the formula $C^{14}H^{16}O$.

The yellow colouring matter of carthamus is acid. It has a bitter taste and g colouring power. It combines readily with oxygen, and is converted into a br substance. It unites with oxide of lead, forming the compound $(Pb^2O)^3.C^8H^{10}O^8$.

The red colouring matter of carthamus is used in dyeing, and for the preparatio rouge. The flowers, after being freed as much as possible from the yellow dye repeated washing with water, are pressed and dried, and sent into the market in form of cakes, known in commerce as *safflower*, *Spanish red*, or *China cake*.

For the preparation of rouge, the red colour is extracted by a solution of carbo of sodium, and precipitated by sulphuric acid or by lemon juice previously depurated standing. This precipitate is dried on earthen plates, mixed with talc or French ch reduced to a powder by means of the leaves of shave-grass triturated with it till are both very fine, and then sifted. The fineness of the powder and proportion of precipitate constitute the difference between the finer and cheaper rouge. It is l wise spread very thin on saucers, and sold in this state for dyeing.

Carthamus is used for dyeing silk or cotton of a poppy, cherry, rose, or br orange-red. The cakes of safflower having been disintegrated by steeping in wa the red fibre is washed in sieves as long as the water which runs through acquir yellow colour. It is then put into a deal trough, and sprinkled at different times pearl ashes, or rather soda, well powdered and sifted, in the proportion of 6 lbs. to mixing the alkali well as it is put in. The alkali should be saturated with carb acid. The carthamus is then put on a cloth in a trough with a grated bottom, pl on a larger trough, and cold water poured on till the larger trough is filled; and treatment is repeated, with addition of a little more alkali toward the end, till the thamus is exhausted and become yellow. Lemon juice or sulphuric acid is then po into the bath, till it is turned of a fine cherry colour, and after it is well stirred, silk is immersed in it. The silk is wrung, drained, and passed through fresh b washing and drying after every operation, till it is of a proper colour; after which brightened in hot water and lemon juice. For a poppy or fire colour, a slight ann ground is first given; but the silk should not be alumed. For a pale carnation, a l soap should be put into the bath. All these baths must be used as soon as they made, and cold, because heat destroys the colour of the red fecula. The colours duced by carthamus are very beautiful, but fugitive. (See *Ure's Dictionary of A Manufactures and Mines*, i. 624.)

CARTILAGE. The cartilages consist of a dry flexible tissue, which cont but a small quantity of inorganic matter, and when boiled with water yields ch drin (*q. v.*), a substance resembling gelatin, but differing in certain reactions.

According to Scherer, the cartilage of the ribs contains 40·5 to 50·9 per cent. car 7·0 to 7·1 hydrogen, 14·9 nitrogen, and 27·2 to 28·5 oxygen. (See BONE.)

CARVENE, CARVOL, and **CARVACROL.** (Völckel, Ann. Ch. Pha xxxv. 308; lxxxv. 246; Schweizer, *ibid.* l. 329; Gm. xiv. 283, 414.)—Essenc caraway consists of two essential oils, *carvene*, $C^{10}H^{16}$, and *carvol*, $C^{10}H^{14}O$, which be separated by fractional distillation. The latter, however, is more easily prep by agitating oil of caraway with an alcoholic solution of sulphide of ammoni *sulphydrate of carvol*, $(C^{10}H^{14}O)^2.H^2S$ is then formed, and this compound, decomp by ammonia yields carvol. (Varrentrapp, Handw. d. Chem. 2te Aufl. ii. [2] 81

is a colourless mobile oil, lighter than water, having a slight agreeable
aromatic taste. Boils at 73° C. It is nearly insoluble in water; very
cohol and ether; it absorbs hydrochloric acid, and forms a crystalline com-
h melts at 50·5 C. and consists of $C^{10}H^{16}.2HCl$.

a liquid boiling at 250° C. Specific gravity 0·953. It is resinised by strong
phuric acid, and forms with hydrochloric acid an oily compound containing
. *Sulphydrate of carvol*, $2C^{10}H^{14}O.H^2S$, crystallises from solution in alcohol
dles having the lustre of satin; they are fusible, and when cautiously
ime almost unaltered (Varrentrapp). *Sulphydrate of sulphocarvol*,
S, is produced by passing sulphuretted hydrogen for a long time through
hich the preceding compound is suspended. It then separates as a thick
ssolves in ether, and is deposited therefrom in white flocks. The ethereal
cipitates chloride of mercury and dichloride of platinum; but the precipi-
ot a constant composition. (Varrentrapp.)
ol, a substance isomeric with carvol, is obtained by treating oil of caraway
or again by treating the same oil with iodine, cohobating several times,
the product with potash; as thus obtained, however, it is mixed with
arvacrol is also found among the products of the action of iodine on
729), $C^{10}H^{16}O + 2I = 2HI + C^{10}H^{14}O$. Carvacrol when pure is a colour-
l lighter than water, and soluble in water to a small amount. It has an
odour, and an acrid very persistent taste. Boils at 232° C., giving off
ch irritate the organs of respiration. It burns with a bright very smoky

PHYLLIC ACID. Syn. with Eugenic Acid.

PHYLLIN. $C^{10}H^{16}O$.—This substance, isomeric with common camphor,
in considerable quantity in *cloves*, the dried flower-buds of the clove-tree,
s aromaticus, which is indigenous in New Guinea and the Moluccas, and
Sumatra, in the isles of Mauritius and Bourbon, and in Brazil. It may be
treating cloves with cold alcohol; the liquid in about fifteen days be-
ed with crystals, which may be purified with solution of soda. The cloves
exhausted with ether, and the caryophyllin separated by agitating the
ution with water. Crude oil of cloves also deposits caryophyllin on

llin forms silky colourless needles arranged in radiating groups, destitute
smell. It melts with difficulty and with partial decomposition (Dumas);
about 285° C. (Muspratt). It dissolves sparingly in cold alcohol, easily
cohol and in ether; also in hot caustic alkalis. Strong sulphuric acid dis-
he cold without blackening, but the liquid blackens when heated. Nitric
s it into a resinous substance. (Gerh. iv. 278.)

LHO. The alluvial soil, consisting of ferruginous sand and clay, in which
onds are found.

RILLA BARK. The bark of cascarilla, *Croton eleutheria* and *Cr.*
rubs indigenous in the West Indies. It contains albumin, tannin, a red
atter, a fatty substance, an essential oil having an agreeable odour, wax,
my substance, starch, pectic acid, wood, fibre, and cascarillin, together
um-salt and chloride of potassium. It possesses tonic and aromatic pro-

RILLA, OIL OF. Cascarilla bark contains a volatile aromatic oil,
o 0·37 per cent. (Bley), 0·87 (Trommsdorf). It is dark yellow, some-
bluish tinge; of specific gravity 0·909—0 938; boils at 180° C. or higher
orf). According to Völckel, the first distillate is colourless, of specific
2, and boils at 173° C. (Gm. xiv. 363.)

RILLIN is obtained by treating the aqueous extract of cascarilla bark
of lead, filtering, and precipitating the excess of lead with sulphuretted hy-
liquid evaporated at a gentle heat deposits an amorphous mass, from which,
g with cold alcohol, the cascarillin may be extracted by boiling alcohol.
by recrystallising several times, after decolorising with animal charcoal.
es in needles or in hexagonal plates, which are colourless, bitter, fusible,
e by heat, sparingly soluble in water, more soluble in alcohol, ether, hydro-
and sulphuric acid. The aqueous solution is not precipitated by alkalis,
ate, or subacetate of lead. (Duval, J. Pharm. [3] viii. 91.)

ARDENING. Steel when hardened is brittle, and iron alone is not
ceiving the hardness which steel may be brought to possess. There is, never-
riety of articles in which it is desirable to obtain all the hardness of steel

together with the toughness of iron. These requisites are united by the art
hardening, which does not differ from the making of steel, except in the shor
tion of the process. Tools, utensils, or ornaments intended to be polished,
manufactured in iron and nearly finished, then put into an iron box, toge
vegetable or animal charcoal in powder, and cemented for a certain tin
treatment converts the external part into a coating of steel, which is usually
because the time allowed for the cementation is much shorter than when the
intended to be made into steel. Immersion of the heated pieces in water
the surface, which is afterwards polished by the usual methods. Moxon (
Exercises, p. 56) gives the following receipt: — Cow's horn or hoof is to be
thoroughly dried, and pulverised. To this add an equal quantity of bay
them with stale chamber ley, or white wine vinegar: cover the iron with this
and bed it in the same in loam, or enclose it in an iron box: lay it then on t
of the forge to dry and harden: then put it into the fire, and blow till the lu
a blood-red heat, and no higher, lest the mixture be burnt too much. Take
out, and immerse it in water to harden.

The same end is now more effectually attained by heating the tool red
sprinkling over it ferrocyanide of potassium (yellow prussiate) in fine pow
quenching it in water. Some prefer smearing the surface of the bright iron
made into a thin paste, with solution of the yellow prussiate, drying it slo
heating it nearly to whiteness, and plunging it into cold water, when the
fallen to dull redness. (See *Ure's Dictionary of Arts, Manufactures and*
630.)

CASEIN constitutes the chief part of the nitrogenised matter contained in
of mammiferous animals. It takes its name from *caseus*, the Latin name of chee
is principally composed of casein mixed with fatty matters (butter) and decon
products of casein (carbonate of ammonium and ammoniacal salts of aceti
valeric acids, &c.).

Preparation.—According to the views of Berzelius, Braconnot, and others,
fications of casein are supposed to exist, the one *soluble* in water, the other c
and *insoluble* in water. *Soluble* casein has, however, never been prepared
alkali, and is most probably identical with albuminate of potassium o
(Lehmann). *Insoluble* casein has nearly the same properties and compositi
soluble albumin.

Soluble casein may be prepared as follows: Fresh milk, from which the
been removed, is evaporated at a gentle heat, a portion of the casein becomi
lated, while the rest remains dissolved. The residue is exhausted with ether
to extract fatty substances, and treated with water, which dissolves casein
(sugar of milk); a little alcohol is next added to the aqueous solution, whe
of the lactin is precipitated, the precipitate is washed with weak alcohol, and
of casein is obtained which always contains lactin and alkali. (Gerh. iv. 4

Insoluble casein may be obtained by simply heating creamed milk near to t
point, coagulating the liquid with a few drops of acetic acid, completely e
the coagulum with water, treating with alcohol and ether, drying and powd
residue, and repeatedly digesting it with ether (Dumas and Cahours). Pe
best method is that of Bopp (Ann. Ch. Pharm. lxix. 16). Milk is coagul
hydrochloric acid, the coagulum washed, first with distilled water, and then w
containing 2 or 3 per cent. hydrochloric acid, and finally with cold distilled
jelly is thus obtained, dissolving at 40° C. in a large quantity of water. This
is filtered and carbonate of ammonium cautiously added, and the precipita
washed and exhausted with ether-alcohol. Whatever acid be employed i
agulation, the casein, when treated in the manner described, never contains
of acid, and has always the same composition. (Gerh. *loc. cit.*)

Chemical Properties.—Soluble casein, when prepared in the manner
leaves, after evaporation, an amorphous residue, inodorous, but having a sic
It does not redissolve completely in water, nor does the solution coagulate by
merely becomes covered with a film, which forms again as often as it is
Soluble casein is coagulated by alcohol, a portion at the same time entering
tion; a larger quantity is dissolved by boiling alcohol. The coagulum produc
solute alcohol is completely insoluble in water. Solution of casein is precip
all *acids* (except carbonic acid); the precipitates redissolve in an excess of
the solutions become covered with a film when evaporated in an open vessel.
acids precipitate casein from its acetic acid solution. After the coagula thus
have been well washed with water, they still redden litmus, although the
impart an acid reaction to water, even on boiling. The spontaneous coag
milk is due to the formation of lactic acid (produced by the fermentation of l

alising the alkali in which the casein was dissolved, and thus rendering the bluble.

casein always contains a large amount of mineral matter (when coagulated , 8 to 10 per cent.). Casein coagulated by an acid yields from 1 to 5 per and the ash is never alkaline (Scherer). Casein contains phosphate of a constituent part. Mulder (Arch. f. 1828, p. 155) found in casein 6 per phate of calcium, which is precipitated on coagulating any caseous liquid with lthough enough free acid be added to dissolve any uncombined phosphate of

noist casein is exposed to the air, it soon begins to putrefy, yielding sulphide nate of ammonium, a neutral oily body, having a disagreeable smell, vith butyric and valeric acids; at the same time the undecomposed casein in the ammonia formed (Iljenko, Ann. Ch. Pharm. lxiii. 264). According a crystalline body possessing a most powerful odour, is formed under the imstances. When casein putrefies out of contact with the air, it yields acetic, aleric, and capric acids, as well as ammonia.

owing are the results of the analysis of coagulated casein, deducting ash:

	Scherer.			Rochleder.	Walther.	Verdeil.
	By alcohol.	By the turning of milk.	By acetic acid.	By sulphuric acid.		
. .	53·7	54·0	53·8	53·8	—	—
. .	7·2	7·2	7·4	7·1	—	—
. .	15·6	15·7	15·7	—	—	—
. .	—	—	—	—	1·0	0·9
. .	—	—	—	—	—	—

	Dumas and Cahours.*					
	From cow's milk by acetic acid.	From goat's milk, by acetic acid.	From asses' milk, by acetic acid.	From sheep's milk, by acetic acid.	From human milk, by alcohol.	From blood by weak boiling alcohol †
. .	53·5	53·6	53·7	53·5	53·5	53·8
. .	7·1	7·1	7·1	7·1	7·1	7·1
. .	15·8	15·8	16·0	15·8	15·8	15·9
. .	—	—	—	—	—	—
. .	—	—	—	—	—	—

(Gerh. iv. 487.)

numbers agree very closely with those obtained by the same chemists in the f albumin, except that casein appears to contain less sulphur than albumin rdeil). Casein does not appear to contain any phosphorus, except in the hosphate of calcium.

ated casein is readily soluble in caustic potash; after boiling, the solution ulphide of potassium. When casein is fused with caustic potash, ammonia olved, then hydrogen; the mass, at first dark brown, gradually clears and yellow; it is then completely soluble in water, and contains tyrosin, leucin, sometimes butyrate), and oxalate of potassium, as well as the potassium-salt ile acid having an excrementitious odour (Liebig). If a very weak solution is saturated with casein, the alkaline reaction completely disappears; the so- us obtained is precipitated by all acids except carbonic. Casein dissolves in of phosphate of sodium, and neutralises it at the same time. It also dis- gely in solutions of the alkaline carbonates, of common salt, chloride of am- nitrate of potassium, &c. These solutions do not coagulate by heat, but gradually covered with a film which is insoluble in dilute alkalis and acids. film is formed when milk is heated.

lutions of casein are precipitated by all *earthy and metallic salts*. The pre- with chloride, sulphate, and acetate of calcium and sulphate of magnesium, vn down only on heating the liquid. Compounds insoluble in water and g on exposure to the air, are obtained by heating casein with carbonate of r of barium. The compound of casein and lime, prepared from clotted milk, escible, and is employed in distemper painting. (Gerhardt, *loc. cit.*)

washed casein, while still moist, be digested with water containing 0·0005 per rochloric acid, it dissolves completely. The liquid, filtered from a trace of fat, he rays of polarised light to the left, and has all the characteristics of a solu- bumin. (Bouchardat.)

The ashes varied between 1·5 and 5·4 per cent. The substance was dried 150° C.

See "Physiological Sources of Casein." (p. 812.)

Ozone acts energetically upon casein, the casein being apparently first conv
into a substance resembling albumin, which is again destroyed on prolonging the a
of the ozone (Gorup-Besanez, Jahresb. d. Chem. 1858, p. 63). O. Maschke
that he obtained by this reaction a crystallised compound of casein with a new
(*ibid.* p. 543). Concentrated *hydrochloric acid* turns casein blue or violet, formin
same products of decomposition as with albumin. *Tannin*, from gall-nuts, precipi
the most dilute alkaline solutions of casein. *Mercuric chloride* yields with so
casein a bulky white precipitate, soluble in acetic acid and in excess of alcohol
precipitate does not contain chlorine, and is probably identical with albumina
mercury (Elsner). Soluble casein is also precipitated by *acetate* and *subacet*
lead, by *alum*, *mercurous nitrate*, and *sulphate of copper*. The acetic acid soluti
casein is moreover precipitated by *ferrocyanide*, *chromate*, and *iodate of potassiu*

Casein yields the same products as albumin with sulphuric acid and acid chro
of potassium or peroxide of manganese (Guckelberger). When chlorine is p
through ammoniacal solution of casein, a product is likewise obtained analogous to
produced in the same way from albumin.

The coagulation of milk by rennet (the mucous membrane of the fourth stoma
young calves), is supposed by Liebig to result from the animal matter acting as
ment, and transforming the lactin of the milk into lactic acid; since milk coagu
by rennet at a temperature of 40° C. always has an acid reaction. It appears,
ever, that milk may be coagulated by rennet, even when rendered alkaline b
addition of small quantities of carbonate of soda, so that after coagulation the l
still remains alkaline: it is only necessary to operate at a higher temperature (bet
50° and 60° C.) (Gerh. iv. 490.)

Sources and physiological nature of Casein.—When morbid bile is evaporated,
of coagulated mucus and of a caseous substance is formed (Frerichs, Hann. An
pp. 1 and 2). Moleschott (*Physiologie des Stoffwechsels*, Erlangen, 1351. p. 366
found casein in the fluid filling the interstices of *cellular tissue*, also in the inter
fluid of the *neck-band*. M. S. Schultze found casein in the liquid impregnatin
middle lining of the arteries: in 100 pts. of the dried fibrous lining membrane o
aorta thoracica, out of 17·4—23·1 pts. soluble constituents, 7·24 pts. casein; and i
middle lining of the *carotid*, which contains more contractile fibrous cells than the
in 39 per cent. soluble pts. 21 pts. of casein were found. The juice of flesh appe
contain casein; at least this substance has been found in the liquid pressed from
It is not certain that blood contains casein. Dumas and Cahours have extracted
the coagulum of blood, a substance which has the same composition as casein
analysis of casein), but is soluble in warm alcohol (Ann. Ch. Phys. [3] vi. 415).
richs almost always observed in the soluble constituents of the contents of the *sm*
testine, albuminous compounds sometimes having the properties of albumin, some
of casein. A substance resembling casein is extracted by boiling alcohol fro
contents of the small intestine of the human fœtus, from the fifth to the sixth
(Lehmann). The presence of casein in the *chyle* is exceedingly improbable. (Le

When yoke of egg is treated with ether and water, a coagulum collects unde
yellow stratum of ether. If, after removing the ether, the coagulum be filtered o
washed until the wash-water becomes only opaline by heat, a substance remains o
filter identical with casein prepared by Rochleder's or Bopp's method (Ann. Ch. P
xiv. 253—6; Bopp, *ibid.* lxix. 16—37), only that it contains a little albumin p
salts; the albumin was precipitated by diluting the yoke solution with water (Gm
Handbuch, viii. 2, 282). Casein has been said to exist in *urina chylosa*.
says that the urine of a child twenty-two weeks old, collected in his presence
contained all the constituents of milk. Lehmann and Chevalier were unab
confirm this statement. Lehmann does not deny that albuminoïdal substances ma
into the urine, but with their properties so changed as not to agree with those
known albuminoïdal compound.

Coagulable albuminate is sometimes found in the discharge of *serous* skin.
is not contained in normal *pus*, nor has it been detected with certainty in abn
pus.

The casein of *human milk* is stated by Simon to be yellowish-white and very fr
it absorbed moisture from the air, and was but incompletely precipitated by al
by acetic acid, from its aqueous solution. Casein from *cow's milk* is less solu
water, and becomes viscid and horny on drying. *Canine milk* gives a casein
does not become viscid and horny when dried, and is less soluble in water.

The following are the percentages of casein in milk from various sources. (Gm
Handb. viii. [2] 254, 5.)

AN.). idlen). nois and).	**Cow.** 3·0—3·4 (Boussingault) 4·16 average (Playfair). 5·52 (Vernois and Becquerel).	**Bitch.** 14·6 (Simon). 9·73—13·6 (Dumas). 11·69 (Vernois and Becquerel).	**Ass.** 1·95 (Péligot). 1·70 Gubler and Quévenne). 3·57 (Vernois and Becquerel).
AT. .). s and Bec-	**Sow.** 8·45 (H. Scherer). 7·36 do. Essex sow.	**Sheep.** 15·3 (Stipriaan, Luiscius, and Bondt). 6·98 (Vernois and Becquerel).	**Mare.** 16·2 (Luiscius and Bondt). 3·24 (Vernois and Becquerel).

ble casein of milk is rapidly coagulated by the gastric juice, and then gra-
sted. Milk is the most indigestible of albuminous bodies. A dog digests
nes of cheese in 3—3·5 hours; boiled casein in 7 hours. E. v. Schröder re-
t in the human stomach, 2·5 hours after fresh milk had been taken, casein
ned in the form of amorphous or filmy transparent lumps; and even after
f 3½ hours, undissolved milk globules, adhering to small coagula of casein,
t always found, although the greater part of the milk seemed to have passed
omach. Cheeses which are hard, fat, and poor in salts, are more difficult
n than loosely coagulated, moist, and fresh cheeses (Gmelin, Handb. iv.
The digestibility of casein naturally depends upon its state of aggregation;
of human milk, which coagulates with great difficulty, is more readily
an that of cow's milk, which is more viscid. C. E. L.

N, VEGETABLE. See Legumin.

VA. *Mousache, Cassave, Cassava Bread*, is a kind of starch, obtained
oot of the *maniock* (*Jatropha manihot, L.*) in the West Indies, where this
digenous. The root is grated to a pulp, which is strongly squeezed in bags
The juice contains nearly one-half per cent. of an exceedingly poisonous
atile, and therefore entirely dissipated by the heat on iron plates, to which
l and crumbled pulp is exposed. Of that poison, as obtained by distillation,
rved to kill, with horrible convulsions, in six minutes, a negro who had been
of murder by poison. Cassava may be freed from woody particles by solu-
ion, and evaporation. If in this state it is exposed to heat on an iron plate,
s into mammellated small lumps, called *tapioca*, an agreeable food, which is
ted by means of potato-starch.

flour may be distinguished, by the microscope, from arrow-root, potato-
wheat-starch, by the shape of its particles, which are spherules of $\frac{1}{1000}$ of
diameter, while those of the second and third farina are ellipsoids, varying
d those of the fourth are spherules, clustered more or less together. U.

IL YELLOW. See Lead, Oxychloride of.

A CARYOPHYLLATA. The bark of *Dicyphellium caryophyllatum*
lauraceous tree growing in Brazil. It has an agreeable taste of cloves. an
dour, and contains, according to Trommsdorff, 19 per cent. resin, 8·0 tannin,
d phosphate of calcium, and 59 woody fibre. It also yields an aromatic
containing eugenic acid. (Handw. d. Chem. 2te Aufl. ii. [2] 820.)

A CINNAMOMEA, *Cinnamon Cassia, Chinese Cassia bark*, is the
er bark of *Cinnamonum aromaticum*, a lauraceous tree indigenous in China,
ted in Java. It has a burning taste and aromatic odour, and contains, ac-
Bucholz, 4·0 per cent. soft resin, 14·6 extractive matter, 64·3 woody fibre,
in; volatile oil, &c. According to Mulder, it also contains tannic acid
.) By distillation with salt water, it yields *oil of cassia*, an oil mainly
of cinnamic aldehyde, and nearly identical with the oil obtained from Ceylon

A FISTULA. The fruit of *Bactyrilobium fistula*, a leguminous plant
India and in the interior of Africa. According to Vauquelin, it contains
nt. sugar, and 1·5 gum, together with pectin, gluten, &c.; according to
it contains cassiin. The legume is divided into a number of transverse
with a sweet, slight acid pulp, 100 pts. of which contain, according to Henry:

	Sugar.	Gum.	Tannin.	Yellow colouring matter and mucus.	Water.
Indian .	69·2	2·6	3·9	1·3	23·2
n . .	61·0	6·7	13·2	—	19·0

A BUDS. The undeveloped flowers of *Cinnamonum Louresii* (Nees).
tion with salt water, they yield oil of cassia. (Handw.)

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[*] Casein and extractive matter: average of 89 persons (1·932—7 092).

CASSIIN. A bitter principle obtained from *Cassia fistula*. It is soluble in and in alcohol, and is precipitated therefrom by sulphuric, nitric, or hydrochloric (Caventou, J. Pharm. xiii. 340.)

CASSITERITE. Native oxide of tin. (See TIN.)

CASSITEROTANTALITE. Tantalite from Broddbo in Finland, cont oxide of tin. (See TANTALITE.)

CASSIUS, PURPLE OF. A purple compound of the oxides of gold an (See GOLD.)

CASSONIC ACID. A syrupy uncrystallisable acid, obtained, together oxalic and saccharic acid, by oxidising cane-sugar with nitric acid. It forms a lum with nitrate of silver. The barium-salt appears to contain $C^8H^6Ba^2O^7$. (Sie Institut. xxi. 78.)

CASTELNAUDITE. A mineral from the diamond sands of Bahia in It consists mainly of hydrated phosphate of yttrium, and occurs in imperfect cr or irregular grains, probably trimetric, of greyish-white or pale yellow colour, un adamantine lustre, harder than fluorspar, but scratched by a steel point. (Da Institut. 1853, p. 78.)

CASTILLOYA ELASTICA. A Mexican scrophulariaceous plant, which caoutchouc.

CASTINE. A crystalline basic substance, obtained from the seed of *Vitex castus, L.* It is bitter, insoluble in water, soluble in alcohol, ether, and acids; a crystalline hydrochlorate. (Landerer, Buchner's Repert. liv. 90.)

CASTOR. A variety of PETALITE (*q. v.*).

CASTOREUM. *Bibergeil.*—A substance found in a pair of small sacs si in the genital organs of the beaver (*Castor Fiber* and *Castor americinus*). The three sorts of it, Russian, Bavarian, and American or Canadian. Of these, the R is most valued, though the Bavarian is considered nearly equal to it. Cast when fresh, is soft and unctuous, but becomes hard and firm when dry; it has a or brownish-black colour, and is somewhat shining. It has a peculiar pungent and a bitterish spicy taste, which irritates the throat; it is used in medicine antispasmodic.

According to Brandes, Russian and Canadian castoreum differ considerably in position, as shown by the following table:

Volatile oil	1·00	2·00
Castoreum resin	13·85	58·60
Cholesterin	—	1·20
Castorin	0·33	2·50
Albumin	0·05	1·60
Glutinous substance	2·30	2·00
Extract soluble in water and alcohol	0·20	2·40
Carbonate of ammonium	0·82	0·80
Phosphate of calcium	1·44	1·40
Carbonate of calcium	33·60	2·60
Sulphates of potassium, calcium, and magnesium	0·20	—
Gelatinous substance extracted by potash	2·30	8·40
Gelatinous substance, extractable by potash, soluble in alcohol	—	1·60
Membranes, skin, &c.	20·03	3·30
Water and loss	22·83	11·70
	98·95	100·10

Wöhler by distilling Canadian castoreum with water, obtained phenic acid, to with benzoic acid and salicin; he suspected also the presence of ellagic and s acid. Lehmann found bile in fresh castoreum, by Pettenkofer's test; also a sebates and urates, and an albuminoïdal substance. Laugier, Brandes, Batk Riegel, found benzoic acid. Lehmann found, as the mineral constituents of cast a small quantity of chloride of sodium, sal-ammoniac, and other soluble salt phosphate of sodium and ammonium, and an abundance of phosphate of calciu phosphate of magnesium.

A substance resembling castoreum is likewise secreted by the prepuce (*Prep penis* and *clitoridis*) of man and of the horse. Lehmann gives the following t the composition of: A. Fresh German castoreum; B. Smoked Russian; C. Can D. *Smegma præputii* of the horse; E. of man:

	A.	B.	C.	D.	E.
extract . . .	7·4	2·5	8·2	49·9	52·8
extract . . .	67·7	64·3	41·3	9·6	7·5
tract . . .	2·6	1·9	4·8	5·4	6·1
id extract . . .	14·2	18·5	21·4	5·4	9·7
„ consisting of ate of calcium and al- oïdal substance . .	2·4	3·4	5·8	2·8	5·6
of skin . . .	5·7	9·4	18·4	26·8	18·5
	100·0	100·0	99·9	99·9	100·2

extracts contained saponifiable fats, cholesterin, and castorin, and a fat
very finely divided in water.

resin is obtained by evaporating the mother-liquor of castorin (*vid. inf.*)
xhausting the residue with water, then dissolving in alcohol, and eva-
is black-brown, shining, brittle, nearly insoluble in ether, soluble in
is, and precipitated therefrom by acids.

-oil, obtained by distilling castoreum with water, is pale yellow, viscid,
ble in water, easily in alcohol, and has a sharp bitter taste. Russian
lds 2 per cent. of this oil; Canadian 1 per cent. (Handw. d. Chem. 2^{te}
.034.)

IN. A fatty substance obtained from castoreum. A solution of castoreum
lcohol saturated while warm, yields on cooling a deposit of ordinary fat,
her-liquor deposits crystals of castorin by slow evaporation. This sub-
purified by repeated crystallisation, forms delicate, transparent, four-sided
ng a faint taste and smell of castoreum. It melts in boiling water, and
cooling to a hard translucent, pulverisable mass. It is but sparingly
d alcohol; ether dissolves it readily; volatile oils only when warm. It
latilise with vapour of water. It dissolves without alteration in boiling
ric acid, in strong acetic acid, in caustic alkalis. According to Brandes,
culiar compound with nitric acid. (Gerh. iv. 280.)

OIL. This oil, much used in medicine as a purgative, is extracted from
Ricinus communis, a euphorbiaceous plant cultivated in the West Indies
arm climates. It is viscid, yellowish, odourless, and has a faint taste,
nes acrid when the oil is rancid. It solidifies at − 18° C. Specific
at 12° C. It is distinguished from other oils by its easy solubility in
ether. It is a mixture of several glycerides. When saponified by an
lds a soap perfectly soluble in water, and from which mineral acids sepa-
re of acids, oily at common temperatures, and consisting mainly of ricino-
$H^{34}O^3$. When this oily mixture is dissolved in a third of its volume of
the solution is cooled to − 15° or − 12° C., it deposits a small quantity of
les, apparently consisting of stearic and palmitic acids.
gives by analysis:

	Saussure.	Ure.	Lefort.	
n . . .	74·18	74·00	74·58	74·35
ogen . .	11·03	10·29	11·48	11·35
en . . .	14·79	15·71	13·94	14·30
	100·00	100·00	100·00	100·00

converts castor-oil into ricinolamide, $N.H^2.C^{18}H^{33}O^2$. When castor oil is
h potash, sebate of potassium remains in the retort, and an oily liquid
consisting of caprylic or œnanthylic alcohol, and methyl-œnanthyl (see
. 98). Castor-oil treated with a mixture of sulphuric acid and acid
potassium, yields œnanthylic acid and hydride of valeryl. Nitric acid
th violence, and converts it into œnanthylic acid. Peroxide of nitrogen
olidify. Castor-oil dissolved in absolute alcohol, and exposed to the action
ydrochloric acid, is converted into glycerin, and contains ethyl-compounds
he fatty acids previously in combination with the glycerin. Castor-oil
dry distillation, yields hydride of œnanthyl and œnanthylic acid, together
uantities of acrolein and solid fatty acids. (Gerh. ii. 903.)

YSIS, or *Contact action.*—Terms applied by Berzelius and Mitscherlich
s of chemical action in which a substance appears to induce decomposition
ody, without itself undergoing perceptible alteration, or at all events with-
into combination with either of the elements of that compound. (See
TION.)

LEIITE. A silicate containing zirconium, from the island Lamö, near

Brevig, Norway, together with zircon, leucophane, mosandrite, and tritomite perfect prismatic crystals, with perfect basal cleavage. Specific gravity 2·8. Ha near 6. Opaque, with light yellowish-brown colour, and little lustre. Melts to a white enamel before the blowpipe on platinum; gives a colourless glas borax; blue with cobalt-solution. Dissolves easily in hydrochloric acid w gelatinising. Mean of analyses:

SiO^2	Zr^2O^3	Al^2O^3	Na^2O	$Ca''O$	$Fe''O$	H^2O	
46·67	29·57	0·92	10·45	4·13	0·56	8·96	= 101·

agreeing nearly with the formula $3(M''O.SiO^2) + 2(Zr^2O^3.3SiO^2) + 2aq.$, which conia be regarded as a protoxide ($zr = \frac{2}{3}Zr$), may be reduced to that of a meta

$(M''\overset{\bullet}{zr}{}^2)Si^3O^9 + aq.$ (Weibye and Sjögren, Pogg. Ann. lxxix. 299; Dana, i

CATAWBARITE. A name given by Lieber (Sill. Am. J. xxviii. 148 rock which accompanies itacolumite, and appears to stand, as a magnesium slate, between itacolumite and itabirite.

CATECHU, formerly called also *Terra japonica*, is an extract rich in obtained by boiling in water the parts of several plants growing in India, and tinguished into three sorts in commerce. 1. Bombay Catechu, from the *catechu*, is prepared by boiling the fruit of the *areca* palm in water, the first p of the decoction being the strongest, and affording the quality called *Cassu*, th portions, the weaker sort called *Coury*. The best occurs in dense irregular lum a dark brown colour. It is opaque, with an even, slightly unctuous, shining fr Another variety called *catechu verum* has a somewhat reddish-brown colour, lustre, a splintery conchoïdal fracture, and is translucent on the edges. B catechu is almost entirely soluble in boiling water, yielding a dark brown liquo rich in tannic acid, and affording copious precipitates with solution of glue an sulphuric acid.

2. Bengal Catechu, is obtained from the *Acacia* (*Mimosa*) *Catechu*, by the twigs and unripe pods in water. It has a lower specific gravity, is of a pale colour, with a yellowish cast. It is opaque, with a glimmering lustre on th tured surface only, and traversed by dark brown shining stripes. When treate cold water, it leaves a large residuum, but boiling by water it is mostly taken u solution contains less tannin, but more *catechin*, than the Bombay sort.

3. The third kind, called Gambir Catechu, is referred to the *Nauclea* (*U Gambir*, from which also kino is obtained. It occurs in cubical pieces of 1 to 1½ opaque, and of a brown yellow or bright yellow colour. Their fracture is eve dull. It is little soluble in cold water, but almost completely in boiling wat solution affording copious precipitates with glue and sulphuric acid.

4. A fourth kind called Egyptian or Nubian Catechu, is said by Landere obtained by the collectors of gum by boiling the fruits of gummiferous acaci to be exposed for sale in the bazaars of Smyrna, and at Constantinople. It is most part soluble in water, but differs from the other varieties in many respects

All kinds of catechu dissolve in great measure in alcohol; and soften with The specific gravity of good Bombay catechu is 1·39; of Bengal catechu 1·28; the Gambir variety, 1·40. Catechu is used as an astringent in medicine, and fo ning leather, either alone or mixed with oak bark. The comparative value of c for tanning may be measured by the proportion of gelatin which is required to p tate all its tannin. Catechu is also used in dyeing, especially for silk and wool. treated with nitric acid at 45° C., it yields a bright yellow powder, possessing properties of picric acid, but much more soluble in water. Silk and wool may be dyed in the aqueous solution.

Catechu has lately been much used to prevent the formation of boiler incrust or to remove them when formed; the quantity required is such as will slightly the water. (Newton, Rep. of Patent Inventions, 1858; Dingl. pol. J. cxlviii.

Catechu is *mainly* composed of two principles, *catechin* and *catechutanni* together with a brown colouring matter.

CATECHIN, *Catechucic acid*, or *Tanningenic acid*, is obtained from Bengal c by digesting it for 24 hours in cold water to extract the tannin, and then boili residue several times with water. The yellow catechucic acid which deposits itself the cooling is to be collected upon a filter, washed repeatedly with cold wate finally dissolved in six times its weight of water with purified bone-black to decolo White catechucic acid separates from the hot filtered solution as it cools. It to be washed on a filter with cold water, quickly dried on bibulous paper, an completely under the receiver of the air-pump. Other processes, but less simpl been prescribed.

Pure catechin is a white powder composed of very small silky needles. It di in 1133 pts. of water at 17° C., forming a colourless tasteless solution, which

colour of litmus; it dissoives in 3 pts. of boiling water (forming a solution
an acid reaction), in 5 or 6 pts. of cold alcohol, 2 or 3 pts. boiling alcohol
old ether and 7 to 8 pts. boiling ether. According to Zwenger's analysis
·3 per cent. carbon and 4·8 hydrogen, whence Zwenger deduces the formula

nelts at 217° (Zwenger), and solidifies to a translucent, amorphous, brittle
drying at 100° C. it gives off 4·4 per cent water when melted. When
its melting point, it turns brown, and intumesces, giving off water and
. By dry distillation it yields an empyreumatic oil and an acid watery
yields by evaporation crystals of pyrocatechin or oxyphenic acid (*q. v.*).
neral acids dissolve catechin without altering it; strong acids decompose
ng sulphuric acid it forms a deep purple liquid.
loes not form definite compounds with bases. It absorbs ammonia, but
gain in vacuo. The fixed alkalis colour it yellow, brown, and black. It
ompose alkaline carbonates, or precipitate the solutions of hydrate or
cium or barium. It forms a white precipitate with acetate and subacetate
k green with ferric chloride; greenish-black or violet with ferroso-ferric
own or black with sulphate of copper; brown or black with salts of silver,
tinum, the metals being reduced. These decompositions often take place
only, or on heating the liquid, and are always accompanied by decompo-
catechin. Solutions of gelatin, starch, tartar-emetic, and salts of quinine
are not precipitated by catechin. (Gerh. ii. 882).

-TANNIC ACID. *Cachoutannic acid. Tannin of Catechu.* To ob-
d, the aqueous infusion of catechu is heated with dilute sulphuric acid,
liquid has been clarified from the colouring matter, &c., thereby thrown
sulphuric acid is added as long as a precipitate continues to form. This
washed on a filter with dilute sulphuric acid, pressed between paper, and
pure water, the solution digested with carbonate of lead, the solid matter
filter, and the filtrate evaporated in vacuo. The product thus obtained is
e-solution in ether containing alcohol. Another mode of preparation is to
dered catechu with ether in a displacement-apparatus and evaporate the
tion. A yellowish porous mass then remains resembling gallotannic acid.
nic acid has a purely astringent taste, and resembles gallotanic acid in
properties, but is distinguished therefrom by not precipitating tartar-
by forming a greyish-green precipitate with ferric salts. It does not
errous salts. It is soluble in water, alcohol, or ether, insoluble in oils
nd volatile; its solutions are precipitated by gelatin. It is but slightly
ater acidulated with sulphuric acid, though more so than gallotannic acid.
to Pelouze, catechutannic acid contains $C^{16}H^{18}O^{8}$.
nnic acid softens when heated, and yields by distillation a yellow empy-
together with a watery liquid which gives a greenish-grey precipitate
alts, and is coloured brown by alkalis.
on of catechu-tannic acid alters quickly by exposure to the air, becoming
ving on evaporation a substance which no longer re-dissolves completely in
ording to Delffs, catechin is one of the products of the decomposition.
of catechutanuic acid are too unstable to be prepared in the pure state.
m-salt is very soluble, and precipitates gelatin after addition of an acid.
tannates of the earth-metals and heavy metals form sparingly soluble pre-

EDULIS. The leaves of this plant, called *Kât* by the Arabs, are brought
erior to Aden; they are said to produce sleeplessness and an agreeable
tement.

RTIN. The purgative principle of senna (the leaves and fruits of several
he genus *Cassia*, order *Leguminosæ*). It is prepared by evaporating the
tract of senna, redissolving in water, precipitating with acetate of lead,
ne excess of lead from the solution by sulphuretted hydrogen, and evapo-
ltrate. It is a brownish yellow, uncrystallisable, diaphanous mass, soluble
alcohol, insoluble in ether; its taste is bitter and disgusting. By dry
t yields products free from nitrogen. Alkalis turn it brown; with sub-
ad and tincture of galls, it forms yellow precipitates (Lassaigne and
Ann. Ch. Phys. [2] xvi. 18). Winckler (Jahrb. pr. Pharm. xix. 223) applies
hartin to a bitter substance contained in the berries of the buckthorn
atharticus). (See RHAMNO-CATHARTIN.)

DE, or *Kathode*.—Faraday's term for the negative pole or electrode in the
it, the elements there eliminated being called *cations*, or *kations*. (See
6.)

CATLINITE. A reddish clay stone from the Coteau de Prairies, west
Mississippi. (Jackson, Sill. Am. J. xxxv. 388.)

CAT'S EYE. A translucent quartz of beautiful appearance brought from
Its colours are green, grey, brown, and red of various shades. Fracture impe
conchoïdal. Translucent with vitreous internal lustre. It derives its name
peculiar play of light (*chatoyant*), arising from fibres interspersed. It scratches
is easily broken, and resists the blowpipe. Specific gravity 2·64. Contains, acc
to Klaproth, 95 per cent. silica, 1·75 alumina, 1·5 lime, and 0·25 oxide of iron.
valued for setting as a precious stone.

CAULOPHYLLIN. A resinous medicinal preparation obtained in
America from *Caulophyllum Halictroïdes*. (Buchner's N. Repert. vi. 128.)

CAUSTICITY. The quality possessed by strong alkalis, acids, nitrate
ver, &c., of corroding the skin and flesh of animals. In the old language of s
caustics were divided into the actual, such as red-hot iron and *moxa*, and the p
tial, such as the above-mentioned preparations.

CAVOLINITE. See NEPHELIN.

CAWK. A miner's term for native sulphate of barium.

CEDAR, OIL OF (not to be confounded with *Oleum de cedro*, which is one
names of oil of citron).—A volatile oil obtained from the wood of the Virginian
Juniperus Virginiana, which is used for making pencils, and owes its agreeable
to this oil. It is a soft semi-solid mass, consisting of a liquid hydrocarbon, ced
$C^{15}H^{24}$, and an oxygenated camphor or stearoptene, containing $C^{15}H^{26}O$.

To obtain the camphor, the crude oil is distilled; the distillate is pressed be
linen or calico, to free it from the greater portion of the liquid cedrene which a
to it, and then crystallised from alcohol of ordinary strength, which retains t
of the cedrene in solution.

Cedar-camphor thus purified is a crystalline mass of great beauty and lustre,
an aromatic odour, like that of pencil-wood, but not much taste. It melts at
and boils at 282°. Vapour-density = 8·4. It dissolves very sparingly in wat
freely in alcohol, whence it crystallises in needles having a silky lustre. It gi
analysis, 81 per cent. carbon and 11·8 hydrogen, agreeing with the preceding fo
hence it is isomeric with camphor of cubebs (*q. v.*) By distillation with phos
anhydride, it is resolved into water and cedrene, $C^{15}H^{26}O = C^{15}H^{24} + H^2O$.
pentachloride of phosphorus, it yields an aromatic substance, which has not ye
analysed. Strong sulphuric acid colours it strongly and separates an amber-co
oil (Walter, Ann. Ch. Phys. [3] I. 1. 498). According to Bertagnini (Compt.
xxxv. 800), oil of cedar combines wth the acid sulphites of the alkali-metals.

CEDRENE. $C^{16}H^{24}$.—This body is produced from the concrete portion of
oil by the action of phosphoric anhydride. It is oily, aromatic, and has a p
taste. Specific gravity 0·984 at 15° C. Boils at 248°. Vapour-density 7·5 (
(Walter, *loc. cit.*)

CEDRIN. See CEDRON.

CEDRIRET. One of the products obtained by Reichenbach (J. pr. Che
from the tar of beech-wood; said to crystallise in fine needles. Völckel (An
Pharm. lxxxvi. 331) was not able to find it.

CEDRON. *Simaba Cedron* (Planchon).—A tree which grows in the hottes
of New Granada, and bears fruits resembling the bean of St. Ignatius; they
bitter taste, and are used in that country as medicine. Ether extracts from t
neutral crystallisable fat, insoluble in cold alcohol. The fruit, after exhaustio
ether, yields to alcohol a crystallisable substance, cedrin, which Lewy regards
active principle of the fruit. Cedrin is sparingly soluble in cold water, more sol
boiling water and in alcohol, and crystallises from the solutions in silky needl
is neutral, and has an intensely and persistently bitter taste. (Lewy, Compt.
xxxii. 510.)

CELESTIN. Syn. with CŒLESTIN.

CELLULIC ACID. Syn. with METAPECTIC ACID. (See PECTIC ACID.)

CELLULOSE. $C^6H^{10}O^5$. *Lignin*, *Woody fibre. Ligneux. Zellstoff, Plan
stoff, Pflanzenfaserstoff.* (Payen, *Précis de Chimie industrielle*, 4me éd. ii. 11; G
481; Gm. xv. 123.)—This substance constitutes the essential part of the solid fra
of plants. The cell-walls in the early stages of their development are compos
tirely of it, but as the plant grows, they become incrusted with colouring matter,
and other foreign substances, which in some parts, as in the heart-wood of larg
fill up the entire cavities. Some tissues, however, consist almost wholly of ce
e.g. the pith of the rice-paper plant (*Aeschynomene paludosa*), and the hor

ertain seeds, as those of the phytelephas or vegetable ivory, the date-tree,
, &c. Several manufactured vegetable fabrics, as cotton, linen, hemp, and
te paper, consist of cellulose very nearly pure.

has also been said to exist in the animal kingdom, constituting the chief
mantle of mollusca, and according to Frémy, of the testa or integument of
crustacea; from the analysis of other chemists, however, these substances
e nitrogenous (see CHITIN). According to **Virchow** (Compt. rend. xxxvi.
ellulose is found in degenerated human spleen and in certain parts of the

est method of obtaining pure cellulose, is to wash white cotton, unsized
linen, or elder-pith, with a hot solution of caustic potash or soda, then
ilute hydrochloric acid, then with ammonia, washing thoroughly with water
plication of each of these reagents, and lastly with alcohol and ether; it
cessary to repeat this series of operations two or three times. To obtain
se from wood, it is necessary, after boiling the wood with potash till the
nost dry, to treat it with chlorine-water or with a weak solution of chloride
eating these successive operations several times, in order to free the cellular
the encrusting matter which is so intimately united with it. The vege-
in the excrements of herbivorous animals furnish a convenient source of
ecause the encrusting matter has been already removed or disintegrated to
ent by the process of digestion, so that the cellular substance which remains
ier to purify than the tissue of the plant in its natural state.

thus purified is white, translucent, of specific gravity about 1·5, insoluble
lcohol, ether, and oils, both fixed and volatile. When quite pure, it is un-
the air; but as it exists in wood, in contact with azotised and other easily
atters, it gradually decomposes in moist air, undergoing a slow combustion,
converted into a yellow or brown friable substance called *touchwood.*

e of aggregation of cellulose varies with its origin. In its less compact
n Iceland moss, it is easily disintegrated by boiling with *water*, and con-
a soluble substance, viz. dextrin; but in its ordinary denser form, as in
, cotton, &c. it resists the action of water, and even of more energetic
r a long time.

ulphuric and *phosphoric acid* disintegrate cellulose at ordinary temperatures,
t it into dextrin, a substance isomeric with cellulose, without colouring
r be then added and the mixture boiled, the dextrin is converted into
hin strips of paper or linen, triturated with strong sulphuric acid added drop
e converted, after some time, into a viscous mass consisting of dextrin, and
this mass with water, it acquires the property of reducing copper-salts in pre-
alkali, and after some hours' boiling is completely converted into glucose.

paper plunged for a few seconds into sulphuric acid diluted with half to a
bulk of water, and then washed with weak ammonia, undergoes a very re-
lteration, being converted, without change of composition, into a tough sub-
much resembling animal parchment, and applicable to the same purposes.
tion of this remarkable substance was first noticed in 1847, by Messrs.
and Figuier, who gave to it the name of *Papyrin.* The discovery re-
wever, without practical application till the year 1857, when it was again
to notice and patented in this country by Mr. W. E. Gaine; and the ma-
ed *vegetable parchment*, or *parchment paper*, is now manufactured in large
Messrs. De la Rue and Co. Besides its application to the same purposes
y parchment, it is largely used for covering pots in which preserves and
kept, and for making shirt-collars, imitation lace, &c. &c.; it is also very
he laboratory, for connecting pieces of apparatus in distillations, and as an
membrane in experiments of diffusion, osmose, &c. That it should have
o long unnoticed after its first discovery is probably due to the circumstance
rs. Poumarède and Figuier, in preparing it, used strong sulphuric acid, of
avity 1·842; and it has since been found that the material thus produced,
ssessing the general characters above described, is not nearly so tenacious
tained with acid diluted to the extent already mentioned. (**Hofmann**,
harm. cxii. 243.)

(linen, for example), boiled for a short time with *moderately dilute sul-*
nitric acid, is converted into a pulpy mass, which still exhibits the compo-
llulose, and does not dissolve sensibly in water. *Strong boiling hydrochloric*
ts cellulose into a fine powder, without change of composition. *Moderatel*
ric acid converts cellulose into a nitro-substitution-product, resembling
$C^6H^9(NO^2)O^5$ (*q. v.*) With *very strong nitric acid*, or a mixture of strong *nitric*
ric acids, higher substitution-products are formed, viz. $C^6H^8(NO^2)^2O^5$ and
O^5 called **gun-cotton**, or **pyroxylin** (*q. v.*)

Caustic potash or *soda* disintegrates cellulose but slowly, and with the more co
varieties the effect is merely superficial. When equal parts of potash and cel
moistened with water, are heated in a closed vessel, hydrogen is evolved, and
spirit distils over, while formic, acetic, and carbonic acids are produced, and r
with the alkali. Melted hydrate of potassium converts cellulose into malic acid.

Cellulose in all its forms is immediately blackened by *fluoride of boron.*

When *chlorine gas* is passed into water in which cellulose is suspended, the cel
is rapidly oxidised, with evolution of carbonic acid; the same effect is produc
gently heating cellulose with the solution of a *hypochlorite:* hence in bleaching
or linen fabrics, paper-pulp, with hypochlorites, &c., great care must be taken
use too strong a solution.

Cellulose in its more compact forms is not coloured by solution of *iodine;*
previously disintegrated by sulphuric acid or caustic alkalis, it produces a viole
colour with iodine. In this manner, cellulose may be detected in vegetable t
under the microscope. Some lichens and algæ, Iceland moss for example, give th
colour with iodine after being boiled with water.

Solution of Cellulose.—Cellulose dissolves completely in an *ammoniacal solut*
oxide of copper. This solvent may be prepared by passing air freed from ca
acid into a bottle filled with copper turnings and half filled with ammonia;
placing copper turnings which have been oxidised on the surface by heating th
the air and then reduced by dry hydrogen, in a tall glass vessel, and causing am
to drop through them into a bottle placed below; or again, by directly diss
oxide of copper in ammonia. Silver-paper, or thin filtering-paper, dissolves i
liquid after a while, forming a syrupy solution, which may be filtered after di
with an equal bulk of water. On mixing the liquid thus formed with exc
hydrochloric acid, the cellulose is precipitated in amorphous flakes, which, after wa
with water, are colourless and quite free from copper. Even in this finely divided
cellulose is not coloured blue by iodine, unless it be first subjected to the act
strong sulphuric acid. (Payen.)

Several substances obtained from the solid tissue of plants, and formerly reg
as distinct proximate principles, are now known to be mere modifications of cell
e. g. fungin, from fungi, *medullin*, from the pith of various trees, &c. *Hordein*,
barley, is a mixture of cellulose with starch and a nitrogenous body.

CELTIS. The fruit of *Celtis orientalis* contains 71 per cent. of fleshy pericar
28·3 seeds, the latter consisting of 67·3 husks, and 32·7 kernel; 100 pts. of the k
contain 15·2 pts. oil, and 45·6 ash, of which 40·4 pts. consist of carbonate of ca
and 4·4 of silica.

CEMENT. The term cement is applied to any substance capable of holdi
gether the surfaces of two bodies without mechanical rivets. Cements may be di
into two classes, stony cements, and those of a resinous and glutinous character.

1. The chief stony cements are *common building mortar*, a mixture of lime s
to a creamy consistence, and sharp sand, which hardens partly by drying, part
absorption of carbonic acid from the air; and *hydraulic mortar*, or *Roman Cem*
mixture of slaked lime with *amorphous silica*, which hardens under water to a co
mass of hydrated silicate of calcium. (See SILICATES OF CALCIUM.)

The *mastic cement* of London, much employed for giving to brickwork the har
and appearance of stone, is composed of oolitic limestone, chiefly that of Por
finely ground, mixed with sand and litharge, and made into a loosely coherent
with linseed oil, either raw or boiled. The oil is extemporaneously mixed b
workman with the cement powder on a board by a trowel, and plastered thinl
smoothly over bricks, laths, or any surfaces which are to resemble stones. Th
dust produced by sawing stone slabs, is said to answer a like purpose, when r
with litharge and oil. Analysis shows that the said *mastic* is composed of 35 p
siliceous sand, 62 of limestone, and 3 of litharge. These proportions may, how
be somewhat varied without injury. Too much limestone impairs the hardness
cement; too much sand makes it porous. For every 100 pts. of such a mixture,
7 of oil are required. As this compost is friable, it may be made more duct
keeping it compressed in moulds, for a little time before spreading it by the tr
The surface to which it is to be applied, must be cleaned and oiled beforehand w
brush. It is particularly useful in closing fissures in buildings, and preventing th
gress of moisture through seams.

2. *Resinous* and *glutinous* cements are of many different compositions. Rosi
beeswax melted together, and thickened with more or less fine brickdust, serv
cementing glass and metal works. Asphalt mixed with chalk in due proportion
been used extensively for paving streets and terraces. The bitumen of Seysse
Lobsaun in France, has been largely employed for this purpose. The compost ren
nearly fluid by heat, is applied to bodies dried, and if convenient, previously he

xed with sand, forms a bad composition, which becomes friable and porous to weather.

eight parts of rosin, and one of wax, melted together and mixed with a ity of plaster of Paris, form a very good cement to unite pieces of Derby- or other stone. The stone should be made hot enough to melt the cement, ces should be pressed together as closely as possible, so as to leave as little f the cement between them: this is a general rule in cementing, as the stratum of cement interposed, the firmer it will hold. Melted sulphur same way will answer sufficiently well, if the joining be not required to ong.

mes happens, that jewellers, in setting precious stones, break off pieces by n this case they join them, so that it cannot be easily seen, with gum-mastic, being previously made hot enough to melt it. By the same medium, cameos amel or coloured glass are often joined to a real stone as a ground, to pro- pearance of an onyx. Mastic is likewise used to cement false backs or stones to alter their hue.

llers in Turkey, who are generelly Armenians, ornament watch-cases and ts with gems by glueing them on. The stone is set in silver or gold, and f the setting made flat to correspond with the part to which it is to be t is then fixed on with the following cement: Isinglass, soaked in water up and becomes soft, is dissolved in French brandy, or in rum, so as t ng glue. Two small bits of gum galbanum, or gum ammoniacum, are dis- vo ounces of this by trituration; and five or six bits of mastic, as big a dissolved in as much alcohol as will render them fluid, are to be mixed means of a gentle heat. The cement is to be kept in a phial closely nd when used, it is to be liquefied by immersing the phial in hot water. t resists moisture.

n of shellac in alcohol, added to a solution of isinglass in proof spirit, her cement that will resist moisture.

ommon glue melted without water, with half its weight of rosin, with the a little red ochre to give it a body. This is particularly useful for cement- o their frames.

oxide of iron mixed with oil, are said to form a cement that will harden r.

cement, insoluble in water, may be made from cheese. The cheese should kimmed milk, cut into slices, throwing away the rind, and boiled till it be- ong glue, which, however, does not dissolve in the water. This water being it is to be washed in cold water, and then kneaded in warm water. This o be repeated several times. The glue is then to be put warm on a levigat- nd kneaded with quick lime. This cement may be used cold, but it is better ; it will join marble, stone, or earthenware, so that the joining is scarcely vered.

nseed oil, litharge, red lead, and white lead, mixed together to a proper , and applied on each side of a piece of flannel, or even linen or paper, and n two pieces of metal before they are brought home, or close together, will e and durable joint, that will resist boiling water, or even a considerable f steam. The proportions of the ingredients are not material; but the d lead predominates, the sooner the cement will dry, and the more the contrary. This cement answers well for joining stones of large dimen-

wing is an excellent cement for iron, as in time it unites with the metal into –Take two ounces of sal-ammoniac, one of flour of sulphur, and sixteen of ings or borings. Mix them well in a mortar, and keep the powder dry. cement is wanted for use, take one part of this mixture, twenty parts of borings or filings, grind them together in a mortar, mix them with water to nsistence, and apply them between the joints.

d quick lime mixed with bullock's blood, is often used by coppersmiths to e rivets and edges of sheets of copper in large boilers, as a security to the nd also to prevent cocks from leaking.

of clay, one of iron filings, and linseed oil sufficient to form a thick paste, d cement for stopping cracks in iron boilers.

ry cements are wanted in cutting, grinding, or polishing optical glasses, various small articles of jewellery, which it is necessary to fix on blocks, or r the purpose. Four ounces of rosin, a quarter of an ounce of wax, and four whiting made previously red-hot, form a good cement of this kind, as any ve articles may be fastened to it by heating them, and removed at plea- e same manner, though they adhere very firmly to it when cold. Pitch, rosin, and a small quantity of tallow, thickened with brick-dust, is much u Birmingham for these purposes. Four parts of rosin, one of beeswax, and brickdust, likewise make a good cement, which answers extremely well for knives and forks in their hafts; but the manufacturers of cheap articles of thi too commonly use rosin and brickdust alone. On some occasions, in which tough cement is requisite, which will not crack though exposed to repeated blow fastening to a block metallic articles that are to be cut with a hammer and workmen usually mix some tow with the cement, the fibres of which hold it together.

Excellent water-proof cements are made from caoutchouc (p. 739).

The following composition is a good cement for electrical apparatus:—Five of rosin, one of beeswax, one of red ochre, and two table spoonfuls of pla Paris, all melted together. A cheaper one for cementing voltaic plates into troughs is made with six pounds of rosin, one pound of red ochre, half a po plaster of Paris, and a quarter of a pint of linseed oil. The ochre and pl Paris should be well dried, and added to the other ingredients in a melted sta (See *Ure's Dictionary of Arts, Manufactures and Mines*, i. 641).

CEMENTATION is the process by which one solid is made to penetr combine with another at a high temperature so as to change the properties o them, without liquefaction taking place, being an exception to the general chemic that bodies do not mutually act on each other unless when one or more of fluid. The conversion of iron into steel by absorption of carbon into its inm stance, from a mass of ground charcoal in which it lies embedded while exp strong ignition, is one of the best examples of this process. A like chang place on palladium, iridium, and platinum, in contact with charcoal or silica at heat. When a compact mass of the oxide of nickel or iron is ignited in a lined and covered with charcoal, the carbon exerts its deoxidating and met power to the very centre. The same phenomenon occurs with compact sulp potassium or sodium encased and heated to redness in charcoal, these salts being converted into metallic sulphides. These transformations have been ascribed progressive production of the gaseous oxide of carbon, and to its absorption metals, or its combination with the oxygen of the oxides or acids.

CEMENT COPPER, is the metal precipitated from the blue water of mines or works by plunging iron plates into them. (See COPPER.)

CENTAURIN. See CNICIN.

CENTRALLASSITE. A hydrated silicate of calcium occurring in kidney lumps, together with other minerals, at Fundy Bay. These lumps are coated greenish crust resembling chlorite; below this crust is a thin layer of cerinite; this the centrallassite; and the central portion consists of cyanolite. Centralla hibits a lamellated radiating structure; it is white or yellowish, translucent, b specific gravity 2·45 to 2·46, hardness 3·5, and has an almost waxy lustre. It melt the blowpipe with intumescence to an opaque glass, and forms clear beads with It dissolves in hydrochloric acid without gelatinising. Its analysis is said with the formula $8Ca''O.15SiO^2 + 5aq$. (H. How, Edinb. N. Phil. J. x. 347.)

CEPHALIS. See IPECACUANHA.

CEPHALOTE. *Cerancephalote.*—A name applied by Couerbe (J. Chim. 524) to a yellow elastic fatty substance, insoluble in alcohol, but soluble i which he obtained from the brain. According to Frémy and J. R. Simon, it i ture of the cerebrates of potassium and sodium, with traces of olein and oleoph acid.

CERADIA FUSCATA. A plant indigenous on the coast of Afric exudes an amber-brown resin smelling like olibanum.

CERAIC ACID. An acid containing $C^{20}H^{40}O^3$, said by Hess (Ann. Ch. xxvii. 3) to be formed by oxidation in beeswax; also supposed to be produce preparation of oxalic or saccharic acid by the action of nitric acid on wheat existing also, according to Oppermann (Ann. Ch. Phys. [2] xlix. 240), in a wax. Its existence has not been distinctly proved.

CERAIN. A name applied by Boudet and Boissenot (J. Pharm. xii the portion of beeswax which is sparingly soluble in alcohol, and, according statement, is not saponified by potash. It appears to be chiefly impure myric much as that body is not quite insoluble in alcohol.

CERANCEPHALOTE. See CEPHALOTE.

CERANTIC ACID. An acid found by Braconnot (Ann. Ch. Phys. 484) in the fuel taken out of an antique lamp, probably of the fourth century material was partly soluble in boiling alcohol of 36°. The solution on cooling d

y substance melting at 64° C., probably *cerin:* and the alcoholic mother-
ed a substance, which remained after evaporation, as a white, hard, brittle
g at 51° C.; its alcoholic solution reddened litmus, and by slow evapora-
ed small granular crystals. This more soluble substance Braconnot desig-
ic acid. The portion insoluble in boiling alcohol contained myricin.

IN. The gum which exudes from the cherry-tree, plum-tree, and others
family is only partly soluble in water. The soluble portion exhibits the
f arabin; the remaining portion, which is called *cerasin*, merely swells up in
asin is colourless, semi-transparent, tasteless, and inodorous; easily pul-
rystallisable, insoluble in water and in alcohol, not susceptible of alco-
tation. Treated with nitric acid, it yields 15·5 p. c. mucic acid. According
ompt. rend. xliv. 144) ordinary gum arabic is converted into insoluble
heat of 150° C. This artificial cerasin is reconverted into a soluble gum
l boiling with water, but again becomes insoluble when heated to 150°.

NE or **CERASITE.** Syn. with Horn Lead.

US. The wood of *Cerasus avium*, the bird-cherry, contains 0·28 per cent.,
37 per cent. of ash. The constituents of these ashes are as follows:

	K^2O	Na^2O	$Ca''O$	$Mg''O$	Fe^2O^3	P^2O^5	SO^3	SiO^2	Cl
.	25·9	10·4	35·8	11·4	0·1	9·6	4·1	2·5	trace
.	7·9	15·5	44·7	5·4	0·2	3·5	0·8	21·3	0·4

e fruit of *C. caproniana* contains a large quantity of malic acid.
la is known in Naples, and *C. virginiana* in North America, as deleterious.

E. A mixture of wax with oil or lard, used by surgeons to screen ul-
aces from the air. Sometimes watery liquids are incorporated with the
acetate of lead in lead-cerate. U.

ITE. Syn. with Nephrite.

LIN. A nitrogenous substance closely resembling diastase, obtained by
riès (Compt. rend. xxxvii. 351; xxxviii. 505; xlii. 1122; xlviii. 431;
bran. It is contained in the epispermium, the sixth membrane of the seed,
om without, and possesses the power of converting starch into dextrin,
actic acid. The brown colour of bread made with flour containing bran
e chiefly due to the decomposition of a portion of the flour by the cerealin
(see Bread, pp. 658, 660). Stiff starch-paste is quickly converted into a
y an infusion of bran at 40° or 50° C.

cerealin, bran is treated for six hours with dilute alcohol, the residue
l this treatment repeated three times, whereby the bran is freed from
xtrin, while the cerealin remains unaltered and undissolved. On treating
with water, the cerealin is dissolved, and the aqueous solution evaporated
ves it in the form of an amorphous albuminoïd substance easily soluble in
ble in alcohol, ether, and oils. The solution coagulates at 75° C., also on
lcohol; it is precipitated in flakes by dilute acids, not altered by neutral
peculiar action on starch is prevented by the presence of alkalis. Cerealin
ted is no longer soluble in acids or alkalis, but still possesses the power of
g starch, though slowly. Cerealin retains its power of decomposing starch
t not at higher temperatures, whereas diastase does not lose this power
. In other respects the two bodies appear to resemble each other exactly.
g to recent investigation by Mouriès, bran freed from cerealin, especially
mium, appears to be more active than cerealin itself, and possesses the power
g starch even at 100° C.

LS. *Cerealia. Getreide.*—This name is applied to the grasses which are
r human food, viz. wheat, barley, rye, oats, maize, and rice. They
nost part distinguished by the large quantities of starch, nitrogenous com-
phosphoric acid contained in their seeds, which constituents it is the object
n to develop as much as possible. The several kinds of cereal grain, ex-
, contain nearly the same amount of nitrogen; but in wheat-grain, the
matter (gluten) possesses a peculiar adhesiveness, arising from the presence
us substance called *gliadin*, which is wanting in the other cereals. It is
y which renders wheat-flour so peculiarly adapted for the making of bread

numerous analyses that have been made of the grain and straw of these
elect the following:

d Ogston have determined the amount of water and ash in the grain,
haff of wheat, barley, oats, and rye with the following results (Journal of the
ultural Society, vii. [2] 593—678; Jahresber. f. Chem. 1849, p. 672):

Species and Varieties.	Moisture in 100 pts. of Grain.	Moisture in 100 pts. of Straw.	Moisture in 100 pts. of Chaff.	Specific Gravity of the Grain.	Weight of 1 bushel in lbs.	Ash in 100 pts. of dry Grain.	Ash in 100 pts. of dry Straw.	Ash in 100 pts. of dry Chaff.
WHEAT:								
Hopeton . . .	12·00	13·70	12·00	1·374	60	2·00	4·40	10·43
,, . . .	12·00	12·30	12·00	1·342	59	2·06	4·30	10·58
,, . . .	11·00	12·20	11·00	1·354	61	1·69	4·46	12·74
,, . . .	9·50	—	—	1·412	60	1·72		
,, . . .	11·50	—	—	1·356	56	1·84		
,, . . .	11·50	14·30	13·50	1·403	63	1·81	4·77	14·29
,, . . .	12·00	13·30	13·00	1·382	61·5	1·81	4·92	16·42
,, . . .	12·00	11·80	13·00	1·396	62	1·94	4·61	13·55
,, . . .	12·00	12·00	11·00	1·398	60	1·92	5·85	13·64
,, . . .	12·50	13·70	11·50	1·391	62	2·01	4·82	11·70
,, . . .	13·00	—	—	1·371	—	1·70		
April . . .	11·00	10·80	12·50	1·387	61	2·01	4·18	7·93
Spring . . .	12·00	12·44	12·21	1·373	62	1·92	5·79	18·76
,, . . .	11·00	12·00	11·00	1·376	58	1·95	5·22	12·99
,, . . .	13·00	14·00	12·01	1·370	63	1·83	4·65	16·34
,, . . .	11·00	11·73	11·00	1·363	62	1·79	6·77	17·12
Bristol red . .	11·50	12·13	11·00	1·370	61·7	1·74	4·46	13·16
Clovers red . .	11·00	11·80	11·00	1·383	61·5	1·74	3·61	8·55
Red-chaff Dantzic .	12·50	10·40	13·00	1·397	61	1·55	5·43	14·90
Pipers thick set .	13·50	12·60	12·50	1·350	61	1·71	5·70	9·73
,, ,, .	11·50	10·50	12·50	1·339	59	1·95	12·29	17·12
White-chaff . .	11·50	10·50	12·00	1·313	59	1·74	5·30	11·61
Spalding . . .	12·00	10·50	11·50	1·377	61	2·05	4·05	8·24
White . . .	13·50	12·07	13·19	1·308	60	1·94	3·82	14·97
,, . . .	13·00	14·00	12·00	1·351	61	1·82	4·65	15·29
,, . . .	12·00	11·70	12·00	1·382	60	1·81	7·92	16·31
Creeping . . .	11·50	10·52	13·13	1·375	62	1·76	4·83	18·96
,, . . .	12·50	10·46	12·00	1·394	62	1·96	6·14	17·11
,, . . .	13·00	12·13	12·00	1·387	61	2·18	7·77	16·25
,, . . .	13·00	10·05	12·00	1·376	62	1·72	4·54	13·60
,, . . .	12·00	10·84	13·00	1·367	61·5	1·93	4·18	15·40
,, . . .	11·50	11·00	11·00	1·365	62	1·95	4·74	17·30
,, . . .	11·00	11·93	12·00	1·372	62·7	1·85	5·22	14·83
,, . . .	11·00	13·00	11·00	1·394	63	1·92	4·94	18·50
Hammonds . .	13·50	11·00	16·00	1·354	60	2·24	5·22	16·32
Red Britannia . .	12·00	10·94	13·00	1·369	62	2·07	5·79	16·64
Red . . .	11·50	12·07	13·50	1·352	60	1·98	6·42	15·05
Red-straw white .	11·25	—	—	1·385	61	1·91		
,, ,, .	12·00	12·70	12·50	1·381	62	1·96	4·85	11·52
,, ,, .	12·50	11·80	14·00	1·392	62	1·97	5·30	16·02
,, ,, .	11·50	12·43	13·00	1·362	61	1·81	3·12	8·09
,, ,, .	11·00	12·30	12·00	1·413	63	1·80	4·79	10·73
,, ,, .	11·00	13·19	11·50	1·377	63	2·13	8·47	17·94
,, ,, .	12·00	11·63	12·30	1·388	62·5	1·96	5·60	11·00
,, ,, .	12·00	12·50	12·50	1·386	61	1·94	5·79	12·88
French . . .	11·00	—	—	1·341	—	1·74		
Egyptian . . .	10·00	—	—	1·340	—	2·19		
Polish . . .	11·00	—	—	1·355	—	1·68		
Marianople . .	10·00	—	—	1·369	—	1·88		
Old red Lammas .	12·50	—	—	1·387	—	2·10		
BARLEY:								
Unknown variety .	12·00	—	—	—	—	2·43		
Chevalier . .	10·00	—	—	1·260	—	2·50		
,, . .	16·00	—	—	1·234	—	2·82		
Moldavian . .	11·00	—	—	1·268	—	2·38		
,, . .	16·00	—	—	—	—	2·75		
Chevalier (awn) .	15·00	—	—	—	—	14·23		
OATS:								
Hopeton . . .	9·50	—	—	—	—	2·50		
Potato . . .	10·50	—	—	1·191	—	2·73		
,, . . .	11·00	—	—	—	—	4·30		
Polish . . .	11·00	—	—	1·152	—	2·97		
,, . . .	13·00	—	—	—	—	3·80		
Unknown . .	12·00	—	—	—	—	3·12		
Oat-chaff . .	15·00	—	—	—	—	9·22		
RYE:								
English . . .	15·00	—	—	—	—	1·60		

In the 50 samples of wheat enumerated in the preceding table:

The moisture in 100 pts. of grain	varies from 9·5	to	13·5;	mean*	11·7
,, ,, ,, straw	,, 10·4	,,	14·0	,,	11·7
,, ,, ,, chaff	,, 11·0	,,	14·0	,,	12·
Specific gravity of the grain	,, 1·313	,,	1·413	,,	1·
Weight in lbs. of 1 bushel of grain	,, 58	,,	63	,,	61·
,, of straw to 1000 pts. of grain	,, 730	,,	1327	,,	1047
,, chaff ,, ,,	,, 116	,,	278	,,	181
Amount of ash in 100 pts. of dry grain	,, 1·68	,,	2·19	,,	1·
,, ,, ,, straw	,, 3·61	,,	12·29	,,	5·
,, ,, ,, chaff	,, 7·93	,,	18·76	,,	13·

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* The mean of the whole, not the mean between the extreme limits.

Millon.[2]	22 samples from Lille, Algeria, and Odessa	12·01—17·70	—	1·41—2·14	1·40—2·35	—	9·92—13·81	1·588—2·729			
Polson.[3]	Old American	10·8	62·3	1·2	8·3	3·8	10·9	—	1·6		
	New Scotch	14·8	56·9	1·2	12·4	5·3	7·0	—	1·5		
Poggiale.[4]	Mean of samples not specified	14·5	63·3	1·9	4·2	—	14·4	—	1·7		
Mayer.[5]	Summer wheat	13·47	—	—	—	—	—	2·29	2·19	1·185	
	Winter „ (9 samples)	10·97—13·83	—	—	—	—	—	2·01—2·32	1·89—2·36	0·985—1·163	
	Barley:										
Fehling and Faisst.[1]	5 samples (Wurtemberg)	13·91—15·60	79·53—81·08		2·58—4·55	—	12·01—15·73	—	2·62—3·04	0·95—1·13	1·51—0·86
	2 „ free from husk „	12·97—14·33	78·60—82·92		1·26—1·84	—	13·71—17·46	—	2·10—2·11	0·99—1·09	0·13—0·17
Polson.[3]	New Scotch	12·0	52·7	2·6	11·5	4·2	13·2	—	2·8		
Poggiale.[4]	Mean of samples not specified	13·7	74·5	0·2	3·4	—	7·8	—	0·3		
Mayer.[5]	8 samples	10·75—13·94	—	—	—	—	—	1·90—2·20	—	0·930—1·176	
	Oats:										
Fehling and Faisst.[1]	6 samples (Wurtemberg)	12·47—14·13	70·24—76·41		10·0—11·39	—	10·69—15·59	—	2·65—3·01	0·66—0·98	0·87—1·33
	2 „ free from husk „	14·86—15·06	82·30—82·90		0·92—1·41	—	14·12—14·16	—	2·06—2·13	1·03—1·10	0·14—4·24
Poggiale.[4]	Shelled grain	14·2	61·9	6·1	3·5	—	11·2	—	3·61		
Mayer.[5]	9 samples	11·79—16·40	—	—	—	—	—	1·54—1·92	3·01—3·64	0·801—0·965	
	Rye:										
Fehling and Faisst.[1]	7 samples (Wurtemberg)	12·62—14·70	78·58—85·25		1·24—2·30	—	10·40—15·83	—	1·90—2·30	0·67—0·97	0·11—0·32
Poggiale.[4]	Mean of samples not specified	15·5	65·5	2·0	6·4	—	8·8	—	1·8		
Mayer.[5]	Summer rye	14·16	—	—	—	—	—	2·38	—	1·014	
	Winter „ (10 samples)	11·77—14·31	—	—	—	—	—	1·91—2·38	—	0·903—1·019	
	Maize:										
Polson.[3]	4 samples (American and Russian)	11·5—13·2	50·1—54·8	4·4—4·7	14·9—20·4	2·3—2·9	8·7—8·9	—	1·6—1·8		
Poggiale.[4]	Mean of samples not specified	13·5	64·5	6·7	4·0	—	9·9	—	1·4		
Mayer.[5]	From S sheim	12·94	—	—	—	—	—	1·74	—	0·913	
	Rice:										
Polson.[4]	Patna (purified)	9·8	78·8	0·1	0·2	1·6	7·2	—	0·9		
Poggiale.[5]	Piedmont	13·7	74·5	0·2	3·4	—	7·8	—	0·3		

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[1] Dingler's Polytechnisches Journal, cxxiv. 223; Jahresber. f. Chem. 1852, p. 812. The moisture was determined in the fresh grain; the other constituents in the grain dried at 100° C.

[2] Compt. rend. xxxviii. 85; Jahresber. 1854, p. 791. The amount of dry gluten in the nitrogenous substance varied from 6·0 to 17·04.

[3] Chem. Gaz. 1855, 211; Jahresber. 1855, p. 849. The determinations refer to the grain in its ordinary (undried) state.

[4] J. Pharm. [3] xxx. 180, 255; Jahresber. 1856, p. 809. The determinations refer to the substance dried at 120° C.; the water was determined by heating the substance (? fresh or air-dried) to 120° C. The starch includes dextrin.

[5] Ann. Ch. Pharm. ci. 129; Jahresber. 1857, p. 637. The water was determined in the air-dried grain; the other materials in the grain dried at 100° C.

TABLE III.—*Composition per cent. of the* ASH OF CEREAL GRAINS.

Authorities.	Name of Species and Varieties.	Potash, K^2O.	Soda, Na^2O.	Lime, CaO.	Magnesia, MgO.	Ferric Oxide, Fe^2O^3.	Sulphuric Anhydride, SO^3.	Silica, SiO^2.	Carbonic Anhydride, CO^2.	Phosphoric Anhydride, P^2O^5.	Chloride of Potassium.	Chloride of Sodium.	Ash in 100 pts. of fresh Substance.	Ash in 100 pts. of dry Substance.	Sulphur in 100 pts. of dry Substance
	WHEAT:														
Way and Ogston.[1]	Hopeton: 9 samples	27·1—36·4	0·1—6·1	1·3—8·2	9·9—14·0	0·1—2·0	trace—1·9	1·4—5·6	0·2	40·0—49·2	—	0·3—1·6	1·5—1·8	1·7—2·05	
	Spalding	29·8	5·3	2·9	11·1	0·2	0·1	2·2	0·2	48·2	—	—	1·8	2·05	
	Creeping: 3 samples	28·9—31·2	1·3—2·4	1·5—6·8	12·4—13·1	0·1—1·4	0·6—1·6	1·3—5·3	—	45·6—48·5	—	—	1·65—1·73	1·85—1·95	
	Red-straw white: 7 samples	26·7—31·1	0·6—3·8	1·15—6·9	9·5—14·2	0·1—3·3	0·1—0·6	2·1—9·7	—	46·6—49·6	—	0·34	1·6—1·7	1·8—2·1	
	Old red Lammas	34·2	4·5	3·2	9·6	2·1	0·3	5·5	—	40·6	—	—	1·8	2·1	
	French	32·4	2·3	3·5	13·9	1·0	0·35	3·05	—	43·5	—	—	1·55	1·7	
	Egyptian	36·6	0·5	4·3	11·1	1·2	0·2	5·0	—	41·0	—	—	2·0	2·2	
	Odessa	30·3	1·0	3·2	14·3	0·9	—	4·5	—	45·8	—	—	1·5	1·7	
	Marianople	35·8	9·1	2·06	14·1	trace	0·2	5·0	—	34·4	—	—	1·7	1·9	
T. J Herapath.[2]	Grown on irrigated land: 3 samples	20·0—31·9	8·9—15·0	0·9—1·4	10·6—12·9	—	0·1—0·2	0·1—0·2	—	46·1—48·7	—	0·3—1·7	1·9	2·3	
	Grown on non-irrigated land: 2 samples	33·1—35·4	2·9—3·1	2·2—5·6	9·1—10·1	—	trace	trace	—	48·2—50·0	—	trace	1·9	2·5	
Lawes and Gilbert.[3]	Mean result of 23 samples	29·35	1·1	3·4	10·7	2·4*	—	2·5†	—	49·7	chlorine 0·18			2·0	
	BARLEY:														
Way and Ogston.[1]	Chevalier: 5 samples	20·8—37·2	0·5—1·4	1·5—3·6	2·9—8·7	0·1—2·1	trace—3·7	17·3—32·7	—	26·3—38·8	1·3—5·6	1·0—2·5	2·0—2·3	2·3—2·7	0·7—3·5
	Moldavian: 3 samples	19·8—31·6	0·9—4·9	1·2—4·2	8·2—10·2	0·1—1·0	0·3—0·5	24·6—30·4	—	28·7—38·0	—	trace—1·5	1·8—2·3	2·1—2·6	1·4—2·4
	Long-eared Nottingham	32·0	1·2	3·4	11·0	0·15	trace	21·12	0·5	25·9	—	0·7	2·0	2·20	1·4
	OATS:														

	„ . . .	16·3	5·3	8·35	5·9	0·1	4·0	43·2	0·6	16·2	—	—	3·3	3·8	
	Unknown variety . . .	14 0	1·5	4·2	8·8	0·4	0·1	49 4	—	21·5	—	—	2·75	3·1	
	RYE:														
Way and Ogston.[1]	Unknown variety . . .	33·8	0·4	2·6	12·8	1·0	0·2	9·2	—	30·9	—	—	1·4	1·6	
	Unknown variety . . .	16·6	19·9	11·25	13·0	—	0·5	3·6	—	33·5	—	1·6	1·3	2·65	
	Unknown variety . . .	9·4	16·1	15·3	10.1	2·2¶	2·6	14·6	—	25·1	—	4·1	1·0	1·9	
	MAIZE:														
Way and Ogston.[1]	"Forty-day" .	28·4	1·7	0·6	13·6	0·5	trace	1·55	—	53·7	—	trace	1·4	1·5	2·05
Graham, Stenhouse, and Campbell.[3]	Unknown variety . . .	30·7	—	3·1	14·7	0·8	4·1	1·8	—	44·5	Cl 0·5				
	RICE:														
Zedeler.[6]	Carolina . .	20·2	2·5	7·2	4·25	—	—	1·4	—	60·2	—	—	—	0·375	

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[1] Journal of the Royal Agricultural Society, vii. [2] 593—678; xvii. [2] 497; Jahresber. f. Chem. 1849, p. 671 and Table D to p. 656; also 1850, p. 666, and Table A to p. 660.

[2] Journal of the Royal Agricultural Society, xi. [1] 93; Jahresber. 1850, p. 666 and Table A to p. 660.

[3] Chem. Soc. Qu. J. x. 22.

[4] Sill. Am. J. [2] iii. 100, 318; Jahresber. 1847—1848 p. 1089, and Table B to p. 1074.

[5] Chem. Soc. Qu. J. ix. 46; Jahresber. 1856, p. 818.

[6] Ann. Ch. Pharm. lxxiii. 348; Jahresber. 1851, p. 711 and Table C to p. 708.

* Ferric phosphate.

† With sand and charcoal.

‡ And 0·98 sand.

§ With 0·4 to 1·20 Mn^4O^3.

‖ And 2·3 to 4·4 sand.

¶ And 0·5 alumina.

TABLE IV.—*Composition per cent. of the* ASH OF STRAW AND CHAFF OF CEREALS.

Authorities (see p. 827).	Name of Species and Varieties.	Potash, K^2O.	Soda, Na^2O.	Lime, CaO.	Magnesia, MgO.	Ferric Oxide, Fe^2O^3.	Sulphuric Anhydride, SO^3.	Silica, SiO^2.	Carbonic Anhydride, CO^2.	Phosphoric Anhydride, P^2O^5.	Chloride of Potassium.	Chloride of Sodium.	Ash in 100 pts. of fresh Substance.	Ash in 100 pts. of dry Substance.	
	WHEAT:														
Way and Ogston.	Creeping: straw with chaff	10·5	1·0	5·9	1·25	0·1	2·1	73·6	—	5·5					
	„ „ „	10·3	0·1	7·5	1·6	0·3	3·95	69·7	—	6·6	7·1	6·65			
	„ „ „	12·5	0·25	4·9	1 4	0·1	2·3	69·9	—	8·5					
	Hopeton: „ „	11·8	—	7·1	1·45	0 7	4·45	60·4	—	5·2					
	„ „ „	10·0	0·85	5·4	3·3	1·5	5·6	67·2	—	7·05					
	Red straw white: „	12·8	0·7	3·5	3·3	0·1	3·3	70·5	—	5·8					
	„ „ „	9·5	1·4	7·3	3·5	1·1	2·3	71·5	—	3·4					
	„ „ „	11·8	—	6·8	3·6	0·5	2 2	66·1	—	8·85					
	„ „ straw	18·0	2·5	7·4	1·9	0·45	3·1	63·9	—	2·75	—	—	4·2	4·8	
	„ „ chaff	9·1	1·8	1·9	1·3	0·4	—	81·2	—	4·3					
	BARLEY:														
Way and Ogston.	Chevalier (on clay soil): straw with chaff	11·2	—	5·8	2·7	1·4	1·1	68·5	—	7·2	—	2·1			
	„ (on loam soil): „	14·4	0·3	8·5	1·7	0·2	2·2	62·8	1·26	4·2	—	4 4	5 0	5·5	1·02
	„ (on lime soil): „	20·2	3·3	11·9	2·9	0·3	3·2	48·2	3·55	3·4		3·1	3·3	3·65	0·54
	Moldavian (on clay soil): „	12·7	2·65	5·3	2·65	1·7	2·7	63·3	—	3·2	—	5 7	6·1	6·8	1·56
	Chevalier: awn	7·7	0·4	10·4	1·3	1·5	3·0	70·8	2·0	2·0		1·1	12·1	14·2	
	OATS:														
Way and Ogston.	Potato (on clay soil): straw	21·7	2·6	8·6	5·5	1·1	2·25	19·5	—	5·3	—	3·4	4·7	5·2	1·37
	„ (on sandy soil). „	20·6	3·2	7·5	8·6	0·5	3·4	45·6	4·1	7·0	—	4·1	4·8	5·4	2·12
	Hopeton (on sandy soil): straw	16·1	—	4·9	2·3	2·7	4·4	53·4	—	2·9	8·1	5·2	4·4	4·95	1·94
	Unknown variety: chaff	13·1	4·1	8·65	2·6	1·4	2·5	89·9	0·2	0·3	—	1·2	7·8	9·2	
J. P. Norton.	Potato: husks	2·2	9·0	4·3	2 35	0·3	4·3	74·2†	—	0·7	—	2·4			
	Hopeton (mean of 3 samples): husks	5·7	3 93	2 8	0·7	1·7*	6·5	76·4‡	—	1·8	1·4	0·2			

gston deduce from their analyses of the ash of cereals the following
sions:

of ash is not influenced in any definite manner by the nature of the
s, however, to be greatest on clay soils, less on calcareous, and least on
The strongest straw contains the largest amount of ash. The amount of
aff varies in proportion to that in the straw, not to that in the grain
The amount of ash in the grain varies between much narrower limits
e straw or chaff. It varies as much in different samples of grain grown
il as in samples from different soils, and bears no definite relation either
o variety. But in all cases that were examined, the proportion of ash
was found to vary inversely as the total weight of grain in the crop;
ld appear that the amount of mineral constituents abstracted from the
in is the same whatever may be the actual weight of the crop.
e amount, but likewise the composition of the ash appears to be inde-
nature of the soil: the predominance of any constituent, lime or silica,
the soil by no means leads to a predominance of that same constituent
Neither does it appear that different bases have any tendency to replace
plants. An abundance of soda in the soil or the manure does not cause
ake the place of potash in the plant. Other chemists have, however,
ferent conclusions relating to this point. (See Daubeny, Chem. Soc.
iv. 215.—Malaguti and Durocher, Ann. Ch. Phys. [3] liv. 257.)
ce in the amount of ash in the grain, straw, and chaff relate only to the
be deducted, the remainders exhibit no perceptible difference.
he grain of barley and oats differs from that of wheat-grain only in the
nount of silica contained in the two former; if this be deducted, all es-
nces vanish.
details, see the names of the several cereals (BARLEY, under HORDEUM);
s SOILS and MANURES.

IC ACID. (Frémy, Ann. Ch. Phys. [2] lvi. 168; v. Bibra, *Ver-
ersuchungen über das Gehirn der Menschen und der Wirbelthiere*, Mann-
-A fatty acid contained in the brain. It is obtained by cutting brain
s; treating it repeatedly with boiling alcohol to deprive it of water;
igesting first with cold then with warm ether; distilling off the ether
ion; and digesting the slimy residue with a much larger quantity of
ric acid then remains as a sodium-salt mixed with phosphate of calcium,
c acid in the form of a sodium and calcium-salt, and brain-albumin.
product, it is digested in boiling absolute alcohol slightly acidulated with
which leaves the calcium and sodium undissolved as sulphates, while
kes up the cerebric and oleo-phosphoric acids, and deposits them on
ly, the mixture is washed with cold ether, which dissolves the oleo-
id and leaves the cerebric acid, which is finally purified by recrystal-
l times from boiling ether.
id has a white, granular, crystalline aspect; it is soluble in boiling al-
e in cold ether, easily soluble in boiling ether; in boiling water it swells
ot dissolve. It melts at a temperature near that at which it begins to
d when more strongly heated burns with a characteristic odour, leaving
mbustible charcoal with a decided acid reaction. It consists, according
66·7 per cent. carbon, 10·6 hydrogen, 2·3 nitrogen, 0·9 phosphorus, and
According to Müller and v. Bibra, the phosphorus is not an essential

d is a weak acid, but nevertheless forms salts with all bases. The *am-
ssium-*, and *sodium*-salts are obtained as precipitates, nearly insoluble in
cing an alcoholic solution of cerebric acid in contact with the respective
ta, *strontia*, and *lime* unite directly with cerebric acid, and deprive it of
forming an emulsion with water.

IN. This name has been applied to several substances obtained from
croy in 1793 (Ann. Chim. xvi. 283) obtained a substance which was
, brain-fat, or phosphoretted bile-fat, and was probably a mixture of
ric acid with the substance which separates after some time from al-
h anatomical preparations containing nerves or brain have been pre-
reul applied the same term to a substance obtained from blood-serum,
xture of fats and glycerides containing phosphoric acid. Lastly, Gobley
] xviii. 107) designates as cerebrin, a substance obtained chiefly from
d agreeing essentially in composition and property with Frémy's cere-
pting that it does not exhibit any tendency to combine with bases.
(Ann. Ch. Pharm. cv. 361) has obtained a substance analogous to

Frémy's cerebrin, by triturating brain to a thin pulp with water, heating th
to the boiling point, and treating the separated coagulum with boiling alco
alcoholic extract filtered at the boiling heat deposits a mixture of cholesterin
brin, together with other substances; and on treating this mixture with e
cerebrin remains behind, and may be purified by repeated crystallisation fr
alcohol. It then forms a snow-white powder composed of microscopic spheru
ing with Frémy's cerebric acid in most of its properties, especially in swel
water like starch, and forming an emulsion. It contains 68·45 per cent. car
hydrogen, 4·51 nitrogen, and 15·66 oxygen, whence Müller deduces the emp
mula $C^{17}H^{33}NO^{3}$. It does not dissolve in alkalis or in dilute acids, but is d
at the boiling heat by hydrochloric, sulphuric, and nitric acid. The pro
decomposition by nitric acid is a non-azotised white waxy body, soluble in a
ether. Treated with strong sulphuric acid in the cold, it dissolves with da
red colour, and the solution mixed with a large quantity of water becomes
and deposits a yellowish, tenacious, flocculent substance.

It is most probable that the cerebrin of Gobley and Müller, the cerebrote o
and the cerebric acid of Frémy and v. Bibra contain, as their essential c
one and the same substance, which is likewise present in cephalote and ste
(Handw. d. Chem. 2te Aufl. ii. [2] 888.)

CEREBROL (Berzelius). *Eleene-cerebrol* (Couerbe).—An oily red
stance, insoluble in water, soluble in alcohol and ether, obtained by
(J. Chim. méd. ii. 765; x. 524) from brain. According to Frémy, it is a
olein, oleo-phosphoric acid, cholesterin, and cerebric acid.

CEREBRO-SPINAL FLUID. A serous fluid contained in the sub-a
cavities, and forming a liquid atmosphere round the brain and spinal m
belongs to the class of serous transudates, and is generally distinguished b
small amount of solid constituents, especially of organic matter. These c
are albumin, traces of fat, extractive matter, and the inorganic salts of bl
It contains also a substance which reduces cupric salts, but differs from glu
being resolved into alcohol and carbonic acid by fermentation. Accor
Hoppe (Chem. Centralbl. 1860, p. 42) this substance is soluble in water an
lute alcohol, does not crystallise, either *per se* or with chloride of sodium, is n
tated either by neutral or basic acetate of lead alone, but yields a precipitat
latter in presence of ammonia. It is decomposed by putrefaction.

Hoppe and Schwaberg analysed the cerebro-spinal fluid obtained by pun
two cases of *Spina bifida* and two of *Hydrocephalus internus*, with the fol
sults:—

	Spina bifida.		Hydrocephalus.	
	I. Puncture.	II. Puncture.	I. Puncture.	II. Punct
Water . . .	989·33	989·80	979·01	989·5
Soiled matter .	10·67	10·20	20·99	10·4
Albumin . .	0·25	0·55	11·79	0·7
Extractive matter .	2·30	2·00	1·32	1·5
Soluble salts . .	7·67	7·20	7·54	7·6
Insoluble salts .	0·45	0·45	0·35	0·5

The fluids from the *Spina bifida* were strongly alkaline and perfectly t
The first reduced cupric oxide, the second did not. The second hydroceph
also exhibited the reducing action. The greater amount of albumin in the f
cephalic liquid was due to previous inflammation of the transudent vessels.
d. Chem. ii. [2] 891.)

CEREBROTE. (Couerbe, Ann. Ch. Phys. [2] lvi. 164.) *Brain-*
wachs (L. Gmelin), *Markpulver*, *Myelocone* (Kühn.)—A substance conta
phur and phosphorus, which Couerbe obtained by treating the deposit which
from the alcoholic and ethereal extracts of the brain with ether; cholesterin
solves, and the so-called cerebrote remains. According to Frémy, it is
mixture of cerebric acid with small quantities of cerebrate of potassium
albumin.

CERIC ACID. An acid obtained by treating cerin, the waxy matte
with nitric acid, washing with water, dissolving in alcohol, filtering and e
It is a brownish diaphanous waxy mass, which softens at a gentle heat,
below the boiling point of water. Dissolves readily in alkalis. Yields em
products when heated. Contains 64·2 per cent. carbon, 8·8 hydrogen, and 2
With acetate of *lead* it forms a white precipitate containing 51·1 C, 6·9 H,
and 22·8 O. (Döpping, Ann. Ch. Pharm. xlv. 289.)

CERIN. A waxy substance extracted by alcohol or ether from grated
viously freed from the outer crust. It separates from the solution in yellowi

obtained colourless by recrystallisation. Contains 74·95 carbon, 10·55
d 14·5 oxygen, agreeing nearly with the empirical formula $C^{23}H^{40}O^{3}$.
in boiling water and falls to the bottom. It is not attacked by boiling
own on glowing coals, it volatilises like beeswax, giving off white fumes.
ation it yields a little acid and a large quantity of an oil which solidifies
leaves but little charcoal. Treated with hot nitric acid it yields ceric
with oxalic and carbonic acids. Cork contains from 1·8 to 2·5 per cent.
er. (**Chevreul**, Ann. Chim. xcvi. 170; **Döpping**, *loc. cit.*)
erin was also applied by John to the portion of beeswax which is soluble
it according to Brodie, the substance thus designated is merely impure
q. v.).

or **ALLANITE.** See Orthite.

. A waxy fat obtained from the lignite of Gerstewitz near Merseberg,
orms about 18 per cent. Contains 76·7 to 78·1 C, and 11·1 to 12·3 H.
mon temperatures; melts at 100° C.; sparingly soluble in alcohol; not
yields a crystalline product by distillation. (**Wackenroder**, Ann. Ch.
315.)

A hydrated silicate of cerium, containing also lanthanum and didy-
the chief source of cerium, and is the mineral from which that metal
ined. It is found only in an abandoned copper mine at Riddarhytta in
, Sweden, occurring in compact fine-grained masses of indistinct blackish
also in short six-sided prisms. Specific gravity 4·93. Hardness 5·5.
owpipe it gives off water, but does not melt. It is completely decomposed
ric acid, leaving a residue of silica. According to **Kjerulf** (Ann. Ch.
ii. 12) it does not give off a trace of chlorine when treated with hydro-
and consequently the cerium exists in it wholly as cerous oxide. Kjerulf
ntain:

$Ce''O$	$\left.\begin{matrix}La''O\\Di''O\end{matrix}\right\}$	$Fe''O$	$Ca''O$	$H^{2}O$	MoS^{2}	BiS
56·07	8·12	4·77	1·17	5·29	3·27	0·18 = 99·27

be deduced the formula $2M''O.SiO^{2} + aq.$ or $(M'')^{2}SiO^{4} + aq.$ It generally
a small quantity of yttria.

. *Symbol* Ce. *Atomic Weight* 92.—This metal, which was discovered
ltaneously by Klaproth and by Hisinger and Berzelius, exists, together
um and didymium, in cerite, allanite, orthite, yttro-cerite, and a few other
of somewhat rare occurrence. The most abundant of them is cerite (*vid.*
tract the oxides of the three metals, the cerite is finely pounded and
ne hours with strong hydrochloric acid, or aqua-regia, which dissolves the
es, leaving nothing but silica. The filtered solution is then treated with
s of ammonia, which precipitates everything but the lime; the precipi-
olved in hydrochloric acid, and the solution treated with excess of oxalic
ite or faintly rose-coloured precipitate is then obtained, consisting of the
rium, lanthanum, and didymium: it is curdy at first, but in a few minutes
talline, and easily settles down. When dried and ignited, it yields a red-
er, containing the three metals in the state of oxide. The finely pounded
so be mixed with strong sulphuric acid to the consistence of a thick paste,
gently heated till it is converted into a dry white powder, and this powder
what below redness in an earthen crucible. The three metals are thus
e state of basic sulphates, which dissolve completely when very gradually
d water; and the solution treated with oxalic acid yields a precipitate of
alates, which may be ignited as before.

red-brown mixture of the oxides of cerium, lanthanum, and didymium
d, a pure oxide of cerium may be prepared by either of the following pro-
The mixed oxides are heated with strong hydrochloric acid, which dis-
hole, with evolution of chlorine; the solution is precipitated with excess of
h; and chlorine gas passed through the liquid with the precipitate sus-
The cerium is thereby brought to the state of ceroso-ceric oxide, which is
ved in the form of a bright yellow precipitate, while the lanthanum and
main in the state of protoxides, and dissolve. To ensure complete separa-
age of the chlorine must be continued till the liquid is completely saturated
the solution, together with the precipitate, left for several hours in a
ttle, and agitated now and then. The liquid is then filtered, the washed
reated with strong boiling hydrochloric acid, which dissolves it with evo-
rine, and forms a colourless solution of protochloride of cerium; and this,
with oxalic acid or oxalate of ammonia, yields a perfectly white precipitate

of oxalate of cerium, which may be converted into oxide by ignition (Mosa
2. The red-brown mixture of the three oxides is treated with very dilute n
(1 pt. of nitric acid of ordinary strength to between 50 and 100 pts. of wat
dissolves the greater part of the oxides of lanthanum and didymium, and l
oxide of cerium; and by treating the residue with very strong nitric acid
traces of lanthanum and didymium may be extracted (Mosander, Mari
3. The red-brown mixture of the three oxides is boiled for several hours in
solution of chloride of ammonium. The oxides of lanthanum and didymium
solve, with evolution of ammonia, and sesquioxide of cerium is left in a state
It must be collected on a filter and washed with a solution of sal-ammonia
when washed with pure water, it first runs through the filter, and then s
(Watts, Chem. Soc. Qu. J. ii. 147).—4. Oxalate of cerium obtained as above
with half its weight of pure magnesia, and made up into a stiff paste with w
this mixture when dry is heated to low redness in a porcelain basin, with
stirring. The product is a cinnamon-coloured powder, containing the wh
cerium as ceric (? ceroso-ceric) oxide, in combination with magnesia, oxide
num, and other protoxides. It dissolves completely, with aid of heat, in str
acid, forming a deep brown solution of a double salt, which appears to consi
nitrate in combination with cerous nitrate and the nitrates of lanthanum, d
and magnesium, sometimes also a small quantity of nitrate of yttrium. T
salt separates in splendid rhombohedral crystals having nearly the colou
chromate of potassium. The solution, if diluted with water before thes
have separated, does not yield any precipitate, either in the cold or in boilin
the crystallisation be allowed to go on till lighter-coloured laminated crystal
containing magnesium and lanthanum with very little cerium, the mother-li
deposits, on dilution and boiling, a basic salt of cerium free from all oth
The precipitate is not formed so long as the red double salt remains dissolv
liquid; indeed it redissolves on adding to the liquid a solution of that salt. T
from which the cerium precipitate has separated still retains cerium, whic
separated by repetition of the treatment.

To separate the cerium from the solution of the red salt, it is diluted wi
quantity of water, then boiled, and sulphuric acid added in small quantity a
the resulting precipitate is thereby increased. The cerium is then precipit
yellowish-white, flocculent basic salt, containing both nitric and sulphuric
free from all other metals, which is difficult to wash on a filter, but is easily v
decantation with water slightly acidulated with sulphuric acid. This salt
readily in strong sulphuric acid, and the solution, after reduction with s
acid, yields, with oxalic acid, a white precipitate of pure cerous oxalate.

If it be desired to obtain a basic nitrate of cerium free from sulphuric acid, a
desirable for other preparations, the red solution of the double nitrate must
rated to a syrup, and then poured into a large excess of boiling water sligh
lated with nitric acid. The precipitate thereby formed is washed by decanta
water containing a little nitric acid, and the mother-liquor, together with t
water, is again evaporated to a syrup and treated as before, till nearly all th
is extracted. The addition of nitric acid to the wash-water is essential, as
nitrate dissolves somewhat readily in pure water. It is best to preserve th
tated salt under acidulated water, since it becomes insoluble in acids when d
ignited. (Bunsen, Ann. Ch. Pharm. cv. 40.)

Metallic cerium is obtained by heating the pure anhydrous protochlo
potassium or sodium. It is a grey powder, which acquires the metallic lustre
sure. It oxidises readily, decomposes water slowly at ordinary temperature
at the boiling heat, and dissolves rapidly in dilute acids, with evolution of l
forming a solution of a cerous salt.

Cerium forms three classes of compounds, viz. the *cerous compounds*
dichloride, $Ce''Cl^2$, the protoxide $Ce''O$; the *ceric compounds*, *e.g.* Ce^2Cl^6 a
and the *ceroso-ceric* compounds, which may be regarded as compounds of
two; *e.g.* ceroso-ceric oxide, $Ce^3O^4 = CeO.Ce^2O^3$.

CERIUM, BROMIDE OF. Not known in the anhydrous state. A s
ceric oxide in hydrobromic acid yields by evaporation small crystals of a
bromide, which gives off hydrobromic acid when heated and leaves an oxybro

CERIUM, CHLORIDES OF. Cerium burns vividly when heated i
gas, and forms the *protochloride* $Ce''Cl^2$. The anhydrous chloride may be pr
igniting the sulphide, or the residue obtained by evaporating to dryness a s
the chloride mixed with sal-ammoniac, in a current of chlorine gas. If the
completely excluded, an oxychloride is also produced. The anhydrous chl
white porous mass, fusible at a red heat, and perfectly soluble in water. A

tained in colourless four-sided prisms, by dissolving the hydrated oxide
nate in hydrochloric acid, and evaporating to a syrup. The solution when
he air, turns yellow, from formation of a ceroso-ceric salt.
ide of cerium forms with *tetrachloride of platinum*, an orange-coloured crys-
e salt, $2Ce''Cl^2.PtCl^4.8H^2O$, easily soluble in water and alcohol, insoluble in
o combines with *iodide of zinc*. (Holzmann, Phil. Mag. [4] xxii. 219.)
ic chloride.—Hydrated ceroso-ceric oxide dissolves in cold hydrochloric
g a red solution, which, however, soon gives off chlorine, and is reduced,
completely, to protochloride.

I, DETECTION AND ESTIMATION OF. 1. *Reactions.*—
ds of cerium, ignited with *borax* or *microcosmic salt* in the outer blowpipe
a glass which is deep red while hot, but becomes colourless on cooling. In
me, a colourless bead is formed with a small quantity of the cerium com-
a yellow enamel with a larger quantity.
lts in solution are colourless, have a sweet astringent taste, and redden
when the acid is perfectly saturated. They are distinguished by the fol-
ions: *Sulphydric acid* produces no precipitate. *Sulphide of ammonium*
the hydrated protoxide. *Caustic potash* or *soda* produces a white preci-
hydrated protoxide, which is insoluble in excess, and is converted into
ydrated sesquioxide by the action of chlorine-water or hypochlorous acid.
ecipitates a basic salt. *Alkaline carbonates* form a white precipitate of
nate insoluble in excess. *Oxalic acid* or *oxalate of ammonia* produces a
itate of cerous oxalate, gelatinous at first, but quickly assuming the crys-
cter, and converted by ignition in an open vessel into a yellowish-white
isting of ceroso-ceric oxide. *Ferrocyanide of potassium* produces a white
precipitate; ferricyanide of potassium none. *Sulphate of potassium* pro-
te crystalline precipitate of potassio-cerous sulphate, nearly insoluble in
nd quite insoluble in excess of sulphate of potassium. With dilute solutions
te takes some time to form. This character, together with the behaviour
te and the yellow coloration of the hydrated protoxide by hypochlorous
to distinguish cerium from all other metals.

itative Estimation.—Cerium is precipitated from neutral solutions of
y carbonate of ammonium, as cerous carbonate, or by oxalate of ammonium
alate; and either of these compounds is converted by ignition in an open
ceroso-ceric oxide, which, according to Bunsen, corresponds, *within the
perimental error*, to the formula Ce^3O^4, and contains 81·18 per cent. of
um, or 95·04 per cent. of the protoxide. Another method is to dissolve
ted carbonate in dilute sulphuric acid, evaporate, and heat the residue to
redness, whereby it is converted into the anhydrous sulphate, Ce^2SO^4,
8·95 per cent. of the metal, or 57·45 per cent. of the protoxide.

ation from other Elements.—Sulphydric acid serves to separate cerium
als which are precipitated by that reagent from their acid solutions. From
iron, *cobalt*, *nickel*, *zinc*, *titanium*, *chromium*, *vanadium*, and *tungsten*,
be separated by means of a saturated solution of sulphate of potassium.
inium it may be separated by carbonate of barium, which precipitates
not cerous oxide; from *glucinum* by sulphate of potassium. From
which it is often associated in minerals, it may be separated by a satu-
n of sulphate of potassium, added in excess, the sulphate of yttrium and
eing soluble in excess of sulphate of potassium, while the cerous double
undissolved. From *zirconium*, cerium is separated by treating the boil-
tion with sulphate of potassium, whereby the greater part of the zirconia
d as basic sulphate, while the cerium remains dissolved; to complete the
, a small quantity of ammonia must be added, but not sufficient to satu-
(H. Rose). From *magnesium* also cerium may be separated by sulphate
; from *barium*, *strontium*, and *calcium*, it is separated by ammonia added
ess; or from barium by sulphuric acid, and from strontium and calcium
acid and alcohol; and from the *alkali-metals* by precipitation with oxalate
Bunsen's method of precipitation already described, affords however the
ans of separating cerium from all the metals with which it is found as-
ecially from *lanthanum*, *didymium*, and *yttrium*.

c Weight of Cerium.—The older statements respecting the atomic
s metal, all refer to cerium containing lanthanum and didymium. For this
, Hisinger, in 1814, found the number 91·3 (H = 1), and Otto found 93·6.
thod of removing the lanthanum and didymium had been pointed out by
Beringer (Ann. Ch. Pharm. lii. 134), from the analysis of the di-

chloride $CeCl^3$, deduced the number 95·6, and from that of the sulphate the
92·4.

Hermann, from an analysis of cerous sulphate, in which the sulphuric a
precipitated as sulphate of barium, found for cerium the number 92.

Marignac (Ann. Ch. Pharm. lxviii. 215), by precipitating cerous sulphate
graduated solution of chloride of barium, obtained, as a mean of seven exper
$Ce = 94·52$. Afterwards, however (Ann. Ch. Phys. [3] xxxviii. 148), he rejec
number, and adopted that previously found by Hermann, viz. 92, attributing th
of his former determination to the circumstance, that a portion of the cerous su
had been carried down undecomposed by the barium precipitate, whence the q
of chloride of barium required to precipitate the sulphate came out too low.

Lastly, **Bunsen** has determined the atomic weight of cerium by the analysis
sulphate. Pure basic ceric sulphate, obtained as above described (p. 832), was di
in sulphuric acid, reduced to cerous sulphate by sulphurous acid, the salt evaporat
ignited till all the excess of acid was expelled, and the residue twice crystallise
water. A solution of this salt was precipitated by oxalic acid; the precipitated
converted into ceroso-ceric oxide by ignition in an open vessel; and the sulphu
precipitated from the filtrate by chloride of barium. The ceroso-ceric oxide w
heated in a sealed flask containing very little air. with pure hydrochloric a
iodide of potassium, whereby it was reduced to cerous oxide, and a quantity of
set free equivalent to the oxygen separated from the ceroso-ceric oxide. T
iodine was estimated by Bunsen's volumetric method (ANALYSIS, VOLUMETRIC,
and the corresponding amount of oxygen estimated by the formula $x = \frac{O}{2I}\, a$ (
In this manner, 100 pts. of the ceroso-ceric oxide were found to contain 95·04
oxide and 4·96 oxygen. From this, the quantity of cerous oxide in the ignited
ceric oxide (that is to say, in the original quantity of cerous sulphate), was calc
and the amount of sulphuric acid (SO^3) being likewise found from the precipita
phate of barium, the composition of the cerous sulphate was found to be 57·49
42·51 $SO^3 = 100$, whence the atomic weight of cerous oxide was found from
portion $42·51 : 57·49 = 80 : x$, giving $Ce''O = 108·1$, and therefore $Ce = 92·1$
other experiments gave $Ce = 92·04$ and 92·1.

In accordance with the preceding results, the whole number 92 is generally
as the true atomic weight of cerium.

CERIUM, FLUORIDES OF. *Cerous fluoride*, $Ce''F^2$, is obtained as
precipitate, by adding an alkaline fluoride to a cerous salt. It is but partially
by the action of hydrogen gas and potassium vapour at a red heat. (**Mosan**

Ceric fluoride, Ce^2F^6, prepared in like manner, is a yellow precipitate.
occurs native as *fluocerite*, in brick-red or nearly yellow six-sided prisms and
with very distinct basal cleavage; also massive; specific gravity 4·7. Hardn
It gives off fluorine when strongly heated in a glass tube. It occurs at Fin
Broddbo, near Fahlun, in Sweden. Ceric fluoride also occurs with the fluo
calcium and yttrium, as *yttrocerite* (*q. v.*).

A *hydrated ceric oxyfluoride*, $Ce^4F^6O^3 + 3H^2O$, occurs at Finbo as *fluoc*
yellow crystals with vitreous lustre, supposed to belong to the regular system (
271). A mineral from Bastnäs in Sweden, analysed by Hisinger, yielded r
corresponding to the formula $Ce^4F^6O^3 + 4H^2O$; one from Finbo, analysed by B
was found to consist of $Ce^8F^6O^9 + 3H^2O$, or $Ce^2F^6.3(Ce^2O^3.H^2O)$. (**Dana**, ii.

CERIUM, OXIDES OF. The *Protoxide*, or *Cerous oxide*, $Ce''O$, is o
by heating the carbonate or oxalate in a current of dry hydrogen perfectly free f
It is a greyish-blue powder, which on exposure to the air quickly becomes v
and is converted into yellowish-white ceroso-ceric oxide. *Cerous hydrate* prec
from the solution of a cerous salt by a caustic alkali, is white, but when exp
the air, quickly changes to a yellow mixture of cerous carbonate and ceroso-c
drate (**Rammelsberg**, Pogg. Ann. cviii. 40). The hydrate dissolves rea
sulphuric, nitric, hydrochloric, and acetic acid, the solutions giving the ch
described at p. 833.

Ceroso-ceric Oxide, Ce^3O^4.—This oxide, which may be regarded as a c
of cerous and ceric oxide: $Ce^3O^4 = CeO.Ce^2O^3$, is produced when cerous hyd
bonate, oxalate, or nitrate, is ignited in an open vessel. It is yellowish-white,
a deep orange-red colour when heated, but recovers its original tint on cooling (B
Rammelsberg). Ignited in hydrogen gas, it assumes an olive-green colo
does not diminish perceptibly in weight (**Bunsen**). It is not raised to a high
of oxidation by heating in oxygen gas, or even by fusion with chlorate or hy
potassium (**Rammelsberg**). Nitric and hydrochloric acid have but little acti
it, even at the boiling heat, unless it be mixed with the oxides of lanthanum a

hich case it dissolves readily in hot hydrochloric acid, with evolution of Heated with a mixture of iodide of potassium and hydrochloric acid, it ompletely, with separation of iodine,—a property which has been made Bunsen for determining its composition. Strong sulphuric acid at the boil- onverts it into an orange-red salt, which becomes light yellow on cooling, es with yellow colour in water.

did not obtain ceroso-ceric oxide of constant composition, but supposed it the most part, the composition $3CeO.2Ce^2O^3$, or Ce^7O^9. Rammelsberg, by g the ceroso-ceric sulphate, $3CeSO^4.Ce^2(SO^4)^3$ with potash, obtained a y precipitate which contained $3CeO.Ce^2O^3$, but was quickly converted into xposure to the air

ric Hydrate, $Ce^3O^4.3H^2O$, obtained by passing chlorine into aqueous potash rous hydrate is suspended (p. 831), is a bright yellow precipitate, which dis- ly in sulphuric and nitric acid, forming yellow solutions of ceroso-ceric ydrochloric acid, with evolution of chlorine, forming colourless cerous

xide, Ce^2O^3, does not appear to exist in the free state, inasmuch as ceroso- is not brought to a higher state of oxidation, even by ignition with power- g agents (*vid. sup.*).

M, OXYGEN-SALTS OF. The *cerous salts* are produced by dissolv- xide or carbonate in acids, also by the action of sulphurous acid and other ents on ceric or ceroso-ceric salts. (For their properties and reactions Cerous silicate exists in nature as *Cerite;* the phosphate as *Monazite*, , *Cryptolite*, and *Phosphocerite;* the carbonate, together with fluoride of *Parisite*.

lphate forms sparingly soluble double salts with the sulphates of ammo- sium, and sodium. The potassium-salt, $K^2Ce''(SO^4)^2$, is the least soluble d quite insoluble in solution of sulphate of potassium.

so-ceric salts are obtained by dissolving the corresponding oxide or hy- ds. The solution of the sulphate yields by spontaneous evaporation first crystals, composed of $3CeSO^4.Ce^2.(SO^4)^3 + 18aq.$, and afterwards a yellow, crystalline salt, containing $CeSO^4.Ce^2(SO^4)^3 + 8\,aq.$ By substituting $= 61\frac{1}{3}$ for *cerosum*, C = 92, in ceric sulphate, these formulæ may be re- $\left.\begin{matrix}SO^2)''\\ ''.\,ce''\end{matrix}\right\}O^4 + 12aq.$ and $\left.\begin{matrix}4(SO^2)''\\ Ce''.\,\overset{''}{ce}^3\end{matrix}\right\}O^8 + 8aq.$, respectively. Both salts are de- y water, with separation of a basic salt, containing $2Ce^3O^4.3SO^3 + 6H^2O$, e on addition of sulphuric or nitric acid. The solution of either with sulphate of potassium, a mixture of at least two double salts, in which and cerosum may be regarded as replacing one another isomorphously: ith sulphate of ammonium: the ammonium double salts, when ignited, leave -ceric oxide.

nbohedral nitrate of cerium and magnesium obtained by Bunsen (p. 832) rified, a ceroso-cerico-magnesic salt, containing $Mg^2Ce''(NO^3)^6.(Ce^2)^{vi}(NO^3)^6$ $\left.\begin{matrix}(NO^2)^{12}\\ \overset{\prime}{Mg}{}^2Ce''\overset{''}{ce}^3\end{matrix}\right\}O^{12} + 16aq.$ [As originally obtained, it contains lanthanum um, replacing cerium isomorphously.] Double salts of similar composition l by mixing a solution of this nitrate with the nitrates of potassium and nitrate of nickel, a basic salt containing $\left.\begin{matrix}(NO^2)^{12}\\ \overset{\prime}{Ni}{}^3Ce''\overset{''}{ce}^3\end{matrix}\right\}O^{12}.Ni''H^2O^2 + 24\,aq.$ n, J. pr. Chem. lxxv. 321.)

tence of pure *ceric* salts is by no means certain. Bunsen speaks of a basic te, precipitated by boiling the solution of the magnesian ceroso-ceric salt ned, with sulphuric acid; but he has not given an analysis of it: indeed, *of a pure ceric salt has yet been published.* The so-called basic ceric sul- mentioned, yields, by digestion with caustic potash, not ceric, but ceroso- te (Holzmann). [For further details respecting the oxygen-salts of the several acids.]

M, PHOSPHIDE OF. Said to be obtained, together with phosphate, phosphoretted hydrogen over white-hot ceroso-ceric oxide. (Mosander.)

M, SELENIDE OF. Produced by decomposing cerous selenite with t a red heat. It is a brownish powder, which dissolves in acids, with evo- lenhydric acid. Cerous salts give with alkaline selenides a pale red preci- ably consisting of hydrated selenide of cerium.

M, SULPHIDES OF. *Cerous sulphide*, $Ce''S$, is obtained by igniting the vapour of sulphide of carbon, or by heating an oxide of cerium with sul-

phide of potassium. The first process yields a light powder of the colour of re
the second, a product resembling mosaic gold (Mosander). *Ceric sulphide*
known in the free state, but is said to combine with other metallic sulphides.

CEROLEIN. A substance obtained from beeswax (in which it is said
to the amount of 4 or 5 per cent.) by treating the wax with boiling alcohol, leav
cerotic acid to deposit on cooling, and evaporating the filtered solution. It
soft, melts a 28·5° C., dissolves readily in cold alcohol and ether; is acid to
gives by analysis 78·74 per cent. C, 12·51 H, and 8·75 O (Lewy, Ann. Ch. P
xiii. 438). It is probably a mixture.

CEROLITE or **KEROLITE** (from κηρός wax, and λίθος stone).—This
applied to two or three minerals or mixtures, consisting chiefly of hydrated si
magnesium more or less mixed with silicate of aluminium. They are all
reniform, compact or lamellar, transparent or translucent, white or grey, with
or resinous lustre, and greasy to the touch.

Analyses.—*a.* From Frankenstein in Silesia by Kühn; *b.* from an unknown
by Delesse; *c.* from Zöblitz in Saxony by Melling:

	SiO^2	Al^2O^3	$Mg''O$	$Fe''O$	H^2O	
a . .	46·96	—	31 26	—	21·22	= 99·44
b . .	53·5	0·9	28·6	—	16·4	= 99·4
c . .	47·13	2·57	36·13	2·92	11·50	= 100·25

The first agrees nearly with the formula $Mg^2SiO^4 + 3aq.$ (*Rammelsberg's*
chemie, p. 862.)

CEROPIC ACID. An acid obtained by Kawalier (Ann. Ch. Pharm. lxxx
from the needles of the Scotch fir (*Pinus sylvestris*). The needles are boiled with
of 40 per cent., the alcohol is distilled off, and the residue is mixed with water,
it is separated into a yellowish resin and a somewhat turbid liquid. The
mass is redissolved in alcohol of 40 per cent., the solution precipitated with ac
lead, and the precipitate suspended in alcohol is decomposed by sulphuretted hy
The solution filtered hot deposits ceropic acid in yellowish-white flocks, w
boiling with alcohol and animal charcoal and repeated crystallisation from
may be obtained in white, friable, microscopic crystals, melting at 100° C., and
ing in a waxy mass. The crystals dried in vacuo gave by analysis 74·24 p
carbon and 12·17 hydrogen, whence Kawalier deduces the improbable
$C^{36}H^{34}O^{3}$. The barium-salt gave 65·50 carbon, 10·33 hydrogen, 12·65 oxyg
11·52 baryta, represented by the formula $BaO.C^{36}H^{34}O^{3}$.

CEROSIC ACID. $C^{48}H^{96}O^{2}$.—Obtained by heating cerosin (sugar-ca
with potash-lime, and purified by saponifying with baryta, dissolving the
alcohol, decomposing it with hydrochloric acid, and dissolving the precipitate
oil, whence it crystallises on cooling. It melts at 93°C.; dissolves sparingly in
alcohol and ether. (Lewy, Ann. Ch. Phys. [3] xiii. 438.)

CEROSIN. *Cerosie.*—The wax of the sugar-cane, obtained by rasping
of the cane, especially of the violet variety, and purified by recrystallising
times from boiling alcohol. It then forms delicate white nacreous laminæ, w
not stain paper. Gives by analysis 81·0 to 81·7 C and 13·6 to 14·2 H, agreein
with the formula $C^{48}H^{96}O^{2}$, which represents it as a kind of aldehyde or et
melts at 82° C., is insoluble in cold ether and alcohol, very soluble in boiling
It is very hard and easily pulverised. (Avequin, Ann. Ch. Phys. lxxv. 218;
ibid. lxxv. 222; Lewy, *loc. cit.*)

CEROTENE. $C^{27}H^{54}$.—A hydrocarbon homologous with ethylene, first
by Brodie (Phil. Mag. [3] xxxiii. 378; Ann. Ch. Pharm. lxvii. 199) as a pr
the dry distillation of Chinese wax. The distillate consists of two parts, cero
passing over first, and afterwards cerotene mixed with a certain quantity of oily
which may be removed by pressure. It is purified by crystallisation, first from
ture of alcohol and naphtha, then from ether. It is crystalline, melts betw
and 58° C., and exhibits the characters of the substances which have been con
under the name of *Paraffin* (*q. v.*) When distilled several times, it is complete
formed into a mixture of liquid hydrocarbons, whose boiling points vary from
260° C.

Chlorinated derivatives of Cerotene.—When moist chlorine is passed over
cerotene, the latter assumes a waxy aspect, then becomes gummy, and is ult
converted into a transparent resin, becoming harder as it absorbs more chlorin
reaction takes several weeks to complete, and at different stages of it the fo
compounds are formed:—$C^{27}H^{36}Cl^{18}$; $C^{27}H^{33}Cl^{21}$; $Cl^{27}H^{32}Cl^{22}$. (Brodie.)

CEROTIC ACID. $C^{27}H^{54}O^{2} = C^{27}H^{53}O.H.O.$ *Cerin of Beeswax* (Joh
mische Schriften, iv. 38; Boudet and Boissenot, J. Pharm. xiii. 38: Ettlin

. ii. 267; **Hess**, *ibid.* xxvii. 3; **Gerhardt**, Rev. scient. xix. 5; **Lewy**, Ann. [3] xiii. 438; **Brodie**, Ann. Ch. Pharm. lxvii. 180.)—This acid is the essen- tuent of that portion of beeswax which is soluble in boiling alcohol. It l by treating beeswax several times in succession with boiling alcohol, posit which forms on cooling melts at 70° or 72° C. The acid thus obtained pure. It is, therefore, to be dissolved in a large quantity of boiling alcohol olution precipitated by acetate of lead. The precipitate, after being ex- th the aid of heat by alcohol and ether, is decomposed by concentrated , and the product crystallised from alcohol yields pure cerotic acid. Cerotic lso be obtained very nearly pure by crystallising several times from ether, product which melts at 72° C. The mother-liquors retain a small quantity fatty acid.—Cerotic acid is likewise produced by the dry distillation of ax, and by melting that substance with potash.

otic acid crystallises on cooling from its solutions in small grains, melting The melted mass assumes on cooling a highly crystalline character.

e acid distils without alteration, but the impure acid is decomposed by dis- ielding principally oily hydrocarbons of very variable boiling point, and in solution small quantities of a fatty acid and other oxygenised products. ransforms cerotic acid into *chlorocerotic acid*, $C^{27}H^{42}Cl^{12}O^2$.

tes.—Cerotic acid is monobasic, the formula of its neutral salts being ². The *lead-salt*, $C^{27}H^{53}PbO^2$, is obtained as a white bulky precipitate on olution of cerotic acid in boiling alcohol with alcoholic acetate of lead. The $C^{27}H^{53}AgO^2$, is obtained by precipitating an alcoholic and ammoniacal solu- otic acid with nitrate of silver at the boiling heat.

CEROTIC ACID. $C^{27}H^{42}Cl^{12}O^2$.—Produced by exposing melted cerotic acid to of chlorine for several days, as long indeed as fumes of hydrochloric acid ible. The product is a thick transparent gum of a pale yellow colour.

rotate of sodium is nearly insoluble in water.

rotate of ethyl, $C^{29}H^{46}Cl^{12}O^2 = C^{27}H^{41}Cl^{12}O^2.C^2H^5$, is prepared similarly to the It has the aspect of chlorocerotic acid.

TIC ETHERS. *Cerotate of ethyl*, $C^{29}H^{58}O^2 = C^{27}H^{53}O^2.C^2H^5$, is luced by passing hydrochloric acid gas into solution of cerotic acid in abso- l. It has the aspect of beeswax, and melts at 59°—60° C.

te of Ceryl. Chinese Wax. $C^{54}H^{108}O^2 = \left.\begin{matrix}C^{27}H^{53}O\\C^{27}H^{55}\end{matrix}\right\}O.$ — This is a pecu- substance obtained from China, where it is produced on certain trees by re of a species of *coccus*. It is crystalline, and of a dazzling whiteness, like , but more brittle and of a more fibrous texture. It melts at 82° C. It is crystallisation from a mixture of alcohol and naphtha, then washed with ted with boiling water, and recrystallised from absolute alcohol, which dis- n small quantity only. Chinese wax is not saponified completely by boiling ous potash, but decomposes readily when fused with potash, yielding cero- assium and hydrate of ceryl. By dry distillation it yields cerotic acid and Almost all the wax gathered in China is used there for making candles. It ployed by the Chinese as a medicine.

TIN. Syn. of CERYLIC ALCOHOL OR HYDRATE OF CERYL (p. 838).

TINONE. The acetone of cerotic acid, obtained by careful distillation of lead. (**Bruckner**; J. pr. Chem. lvii. 1.)

XYLIN or *Palm wax* is the produce of the *Ceroxylon Andicola*, and is ob- rasping the epidermis of the tree and boiling the raspings in water. The on the surface in a soft state, while the impurities sink to the bottom. It rther purified by repeated boiling with alcohol. In its natural state it is a hite powder; after purification, yellowish-white. It is nearly insoluble in d melts at 72° C. It has been analysed by **Boussingault** (Ann. Ch. Phys. , **Lewy** (Ann. Ch. Phys. [3] xiii. 458), and **Teschemacher** (Ann. Ch. 270) with the following results:—

	Boussingault.	Lewy.	Teschemacher.
Carbon	80·48	80·73	80·28
Hydrogen . . .	13·29	13·30	13·20
Oxygen	6·23	5·97	6·42
	100·00	100·00	100·00

MEN OF THE EAR. A yellow secretion which lines the external audi- , rendered viscid and concrete by exposure to air. It has a bitter taste,

melts at a low heat, and evolves a slightly aromatic odour. On ignited
gives out a white smoke, similar to that of burning fat, swells, emits a fetid
niacal odour, and is converted into a light charcoal. Alcohol dissolves $\frac{5}{8}$ of it,
evaporation leaves a substance resembling the resin of bile. The $\frac{3}{8}$ which rem
albumin mixed with oil, which by incineration leave carbonate of sodium an
phate of calcium.

CERUSE or *White lead.* See CARBONATES (p. 786).

CERUSITE. Native carbonate of lead (p. 786).

CERVANTITE. Native tetroxide of antimony, SbO^2 or $Sb^2O^3.Sb^2O^5$, f
Cervantes in Spain and at Pereta in Tuscany (p. 324).

CERYL, HYDRATE OF. *Cerylic Alcohol, Cerotin.* $C^{27}H^{56}O = \frac{C^{27}H}{H}$
Produced by fusing Chinese wax (cerotate of ceryl) with potash, digesting th
mass in boiling water, whereby a solution of cerotate of potassium is obtained
cerylic alcohol in suspension; precipitating the cerotic acid with chloride of
and dissolving out the hydrate of ceryl with alcohol, ether, or coal-tar oil.
drate of ceryl, purified by several crystallisations from ether or alcohol, forms
substance melting at 79° C. Heated with potash-lime, it gives off hydrogen
converted into cerotate of potassium:

$$C^{27}H^{56}O + KHO = C^{27}H^{53}KO^2 + 4H.$$

At a very high temperature it distils partly undecomposed, partly resolved in
and cerotene, $C^{27}H^{54} + H^2O$. Chlorine acts upon hydrate of ceryl, producing
parent pale-yellow substitution-product, *chlorcerotal*, containing 37·62 to
4·76 to 4·78 H, and 55·11 to 55·07 Cl, numbers which correspond to the
$C^{27}H^{34\frac{1}{2}}Cl^{13\frac{1}{2}}O$. The action of the chlorine was probably not complete. The
has the appearance of a gum-resin, and becomes electrical by friction. (Brodi
Ch. Pharm. lxvii. 120.)

Hydrate of ceryl treated with excess of sulphuric yields a product whic
washed with cold water, dried in vacuo, and crystallised from ether, has the
tion of *neutral sulphate of ceryl with* 1 *at. water*, $(C^{27}H^{55})^2SO^4 + H^2O$. When p
perfectly soluble in water, especially if a little alcohol is added; the solution ev
at a low temperature leaves the substance in the form of a soft wax. (Brodi

CETENE or *Cetylene*, $C^{16}H^{32}$. (Dumas and Péligot, Ann. Ch. Phys. [2]
Smith, *ibid.* [3] vi. 40.)—A hydrocarbon homologous with ethylene, obtained
tilling cetylic alcohol with phosphoric anhydride, also by distilling cetin (palm
cetyl), and treating the product with potash to saponify the fatty acids which hav
over in the distillation, the cetene then floating on the surface of the liquid.

Cetene is a colourless oily liquid, which stains paper. It boils at 275° C., d
without alteration. Vapour-density 8·007. It is insoluble in water, easily so
alcohol and ether, neutral to test-paper. It has no particular taste. When se
it burns with a very pure white flame, like the fat oils.

Cetene unites with hydrobromic and hydrochloric acids, slowly at ordinary t
tures, somewhat more quickly at 100° C. The compound is decomposed by dist
(Berthelot, Ann. Ch. Phys. [3] li. 81.)

The ethylosulphates (sulphovinates) yield by dry distillation an oily liqui
oil of wine), from which water separates an oily hydrocarbon (*light oil of wine*
boils at nearly the same temperature as cetene; and this oil, when exposed t
low temperature deposits crystals (*camphor* or *stearoptene of wine-oil*), having t
composition.

CETIC ACID. $C^{15}H^{30}O^2$?—Produced, according to Heintz, in very sma
tity in the saponification of spermaceti (p. 840). Crystallises in nacreou
grouped in stars, melting at 53·5° C. Benic acid obtained from oil of ben, an
tearic acid, from the fruit of *Stillingia sebifera*, have the same composition.

CETIN, $C^{32}H^{64}O^2$. (Chevreul, *Recherches sur les Corps gras*, p. 171;
Ann. Ch. Pharm. xlii. 247; Stenhouse, J. pr. Chem. xxvii. 253; Radclif
Ch. Phys. [3] vi. 50.)—A fatty crystalline substance constituting the essentia
spermaceti, the substance which, in the state of solution in an oil, fills the ca
the head of the cacholot, or spermaceti whale, and other cetaceous animals. T
it in a state of purity, spermaceti is treated with cold alcohol, which remove
and the residue is crystallised from boiling alcohol.

Cetin melts at 49° C., and solidifies on cooling in a translucent mass, whic
for the manufacture of candles. Heated to 360°, out of contact with the air,
tilises without alteration; but if heated quickly and in considerable quantit
completely decomposed into a solid fatty acid (palmitic acid), and a liquid hyd

ccompanied, chiefly towards the end of the distillation, by secondary pro-
h as water, carbonic anhydride, carbonic oxide, and olefiant gas. Cetin is
n water. 100 pts. of *alcohol* of 0·821 dissolve 2·5 pts. of it; *absolute alcohol*
dissolve it in larger quantities, and deposit it on cooling in brilliant laminæ.
l attacks it slowly, and converts it into a mixture of œnanthylic, adipic, and
ids.

oiled with caustic alkalis is transformed into hydrate of cetyl and a palmi-
alkali-metal (Smith):

$$\underset{}{C^{32}H^{64}O^2} + KHO = \underset{\substack{\text{Hydrate of}\\\text{cetyl.}}}{C^{16}H^{34}O} + \underset{\substack{\text{Palmitate of}\\\text{potassium.}}}{C^{16}H^{31}KO^2}.$$

observed, however, that the statements of different chemists regarding the
resulting from the saponification of cetin do not quite agree. Chevreul
margaric and oleic acid. Heintz (Pogg. Ann. lxxxiv. 232) obtained a mix-
earic, palmitic, myristic, cocinic, and cetic acids, which he separated by the
olubility of the acids themselves, and of their barium-salts, in alcohol. He
regards cetin, not as a simple proximate principle, but as a mixture of the
of the acids just mentioned. By repeatedly crystallising spermaceti from
obtained at last a small quantity of a fatty substance, which melted at
but in other respects exhibited the characters of cetin, and also its composi-
80·03 C, 13·25 H, and 6·72 O.

ARIA. See Lichens.

ARIC ACID. *Cetrarin.* $C^{18}H^{16}O^8$. (Berzelius, Schw. J. vii. 317;
n. xc. 277.—Herberger, Ann. Ch. Pharm. xxi. 137.—Knop and Schneder-
id. lv. 144.)—Contained, together with lichenostearic acid, in Iceland moss
islandica). To obtain the two acids, the lichen is treated for about a quarter
with a boiling mixture of strong alcohol and carbonate of potassium (15 grm.
rbonate to each kilogramme of alcohol), whereby the acids are dissolved
um-salts. The filtered liquid mixed with hydrochloric acid, deposits the two
ed with a green substance; and by treating this mixture with 8 or 10 times
t of boiling dilute alcohol, the lichenostearic acid is dissolved, while the
cid and the green substance remain undissolved.

te the cetraric acid, which forms the greater part of the residue, this residue
several times with a mixture of ether and an essential oil, for the purpose
ng the green matter; it is then boiled with strong alcohol, which dissolves
ic acid, and on cooling deposits it in slender needles, which are purified by
em with animal charcoal, then dissolving them in potash, and decomposing
sium-salt with hydrochloric acid. (Knop and Schnedermann.)

c acid crystallises in extremely fine capillary needles, of dazzling whiteness.
ure bitter taste, is nearly insoluble in water, sparingly soluble in ether, very
boiling alcohol. The crystals are anhydrous.

c acid turns brown when boiled with water; the alcoholic solution also turns
boiling: this change is much accelerated by the presence of an alkali.
acid colours cetraric acid, first yellow, afterwards red: the mass becomes
and dissolves: and water added to the solution throws down ulmic acid.
oric acid dissolves a small quantity of cetraric acid, the undissolved portion
a deep blue colour. This blue compound is dissolved with red colour by
phuric acid, and reprecipitated blue by water. This blue precipitate dissolves
ture of dichloride and tetrachloride of tin, and alkalis added to the solution
wn a blue lake (Herberger). Cetraric acid is oxidised by *nitric acid*,
oxalic acid and a yellow resin. Chlorine and bromine do not appear to act

c acid decomposes carbonates, and forms yellow salts, soluble in water and
nd having an intolerably bitter taste. It has a great tendency to form acid
e neutral salts cannot be evaporated, even in vacuo, without decomposing
ng brown. The acid salts are precipitated in a gelatinous form, by mixing
l salts with half the quantity of hydrochloric acid necessary to saturate the
ey are difficult to wash, but may be evaporated in the air without turning

holic solution of acid cetrarate of potassium, forms a deep red precipitate
c chloride, the liquid at the same time assuming a blood-red colour.
te of ammonium is obtained as a yellow powder, by treating the acid with
mmonia, of which it absorbs 10·2 per cent. The *lead*-salt, $C^{18}H^{14}Pb''O^8$, is
as a yellow flocculent precipitate, by mixing acetate of lead with cetrarate of
n. The *silver*-salt is a yellow precipitate, which rapidly turns brown.
nd Schnedermann.)

CETYL. $C^{16}H^{33}$.—A monotomic alcohol-radicle not yet isolated, but suppe
exist in a series of compounds homologous with the ethyl-compounds, and derive
spermaceti. The cetyl-compounds at present known are:

Type H.H.O.

Hydrate of cetyl (cetylic alcohol)	$C^{16}H^{33}.H.O$
Oxide of cetyl (cetylic ether)	$(C^{16}H^{33})^2O$
Oxide of cetyl and sodium	$C^{16}H^{33}.Na.O$
Oxide of cetyl and ethyl	$C^{16}H^{33}.C^2H^5.O$
Oxide of cetyl and amyl	$C^{16}H^{33}.C^5H^{11}.O$
Acetate of cetyl	$C^2H^3O.C^{16}H^{33}.O$
Benzoate of cetyl	$C^7H^5O.C^{16}H^{33}.O$
Butyrate of cetyl	$C^4H^7O.C^{16}H^{33}.O$
Stearate of cetyl	$C^{18}H^{35}O.C^{16}H^{33}.O$
Succinate of cetyl	$(C^4H^4O^2)''.(C^{16}H^{33})^2.O$
Sulphate of cetyl and hydrogen	$(SO^2)''.C^{16}H^{33}.H.O^2$
Sulphydrate of cetyl	$C^{16}H^{33}.H.S$
Sulphide of cetyl	$(C^{16}H^{33})^2S$
Cetyl-xanthic acid	$(CO)''.C^{16}H^{33}.H.S^2$

Type HH.

Bromide of cetyl	$C^{16}H^{33}Br$
Chloride of cetyl	$C^{16}H^{33}Cl$
Iodide of cetyl	$C^{16}H^{33}I$
Cyanide of cetyl	$C^{16}H^{33}Cy$

Type NH^3.

Nitride of cetyl, or tricetyl-amine	N.(C
Cetylphenylamine	N
Dicetylphenylamine	N

CETYL, ACETATE OF. $C^{18}H^{36}O^2 = C^2H^3O.C^{16}H^{33}.O$, is produced by t
cetylic alcohol with acetic and hydrochloric or sulphuric acid, precipitating by
dissolving in ether, and evaporating, as an oily liquid, which at a low temperat
difies, after a while, in a mass of needle-shaped crystals, fusible at 18·5° C. (B
Ann. Ch. Pharm. cii. 219.)

CETYL, BENZOATE OF. $C^{23}H^{38}O^2 = C^7H^5O.C^{16}H^{33}.O$.—Obtained by
chloride of benzoyl with cetylic alcohol in equivalent proportion, dissolving the
in ether, and precipitating with alcohol. It forms crystalline scales, which melt at
dissolve readily in ether, and sparingly in alcohol. (Becker, *loc. cit.*)

CETYL, BROMIDE OF. $C^{16}H^{33}Br$.—Produced by the action of brom
phosphorus on cetylic alcohol. It is a colourless solid body, heavier than wate
melted state, insoluble in water, very soluble in alcohol and ether; melts a
When distilled, it gives off hydrobromic acid. (Fridau, Ann. Ch. Pharm. lxxx

CETYL, BUTYRATE OF. $C^{20}H^{40}O^2 = C^4H^7O.C^{16}H^{33}.O$.—Obtained by
heating a mixture of cetylic alcohol and butyric acid to 200° C., and procee
with the benzoate. It is white, neutral, miscible with ether but not with
melts more easily than cetylic alcohol, and when cautiously heated in small q
volatilises without decomposition. (Handw. d. Chem. 2te Aufl. ii. [2] 929.)

CETYL, CHLORIDE OF. $C^{16}H^{33}Cl$. *Hydrochlorate of Cetene.*—Obta
the action of pentachloride of phosphorus on cetylic alcohol. The two bodie
in fragments in a retort, become heated, melt, and act violently on each other
off large quantities of hydrochloric acid. On subsequently distilling the p
oxychloride of phosphorus passes over, and then chloride of cetyl, which
purified by redistillation with a small quantity of pentachloride of phosphoru
ing with boiling water, and drying in vacuo at about 120° C. If it still c
hydrochloric acid, it must be distilled with lime recently ignited. (Dum
Péligot, Ann. Ch. Phys. lxxii. 4.)

Chloride of cetyl is a limpid oily liquid of specific gravity 0·8412 at 12° C., i
in water and in alcohol, but soluble in ether, whence it may be precipitated b
alcohol. It distils above 200° C., with partial decomposition, and by prolonge
lition the whole of the chlorine may be expelled as hydrochloric acid, leaving
(p. 838). It is not acted upon by nitric acid, but strong sulphuric acid decom
eliminating hydrochloric acid and forming cetyl-sulphuric acid. It does not
ammonia. (Tütscheff, Rép. Chim. pure, ii. 463.)

CETYL, CYANIDE OF. $C^{16}H^{33}.CN$.—Obtained in an impure state, by
cetylsulphate of potassium with cyanide of potassium, and extracting wit

Zeitschr. d. gesammt. Naturw. vii. 252; Jahresber. 1856, 579.—Heintz,
. cii. 257; Jahresber. 1857, 445). According to Köhler, it is a solid crys-
stance, melting at 53° C., easily soluble in ether and in hot alcohol; accord-
ntz, it is liquid at ordinary temperatures, but its formation is accompanied
a crystalline solid, which melts at 55·1°, and is probably a mixture of
er with palmitic aldehyde. Heated with potash it appears to yield margaric
O^2. (Köhler.)

, HYDRATE OF. $C^{16}H^{34}O = C^{16}H^{33}.H.O$. *Cetylic Alcohol, Ethal.*
l, *Recherches sur les Corps gras*, p. 171.—Dumas and Péligot, Ann. Ch.
xii. 4; Smith, *ibid.* [3] vi. 40; also, Ann. Ch. Pharm. xlii. 247.—Heintz,
. lxxxiv. 232; lxxxvii. 553.)—This compound is prepared by saponifying
with an alkali, the cetin, or palmitate of cetyl contained in that substance
resolved into an alkaline palmitate and hydrate of cetyl, which latter is
out by alcohol or ether. Dumas and Péligot add 1 pt. of solid hydrate of
by small portions and with constant agitation, to 2 pts. of melted sperma-
the resulting soapy mass with water, and then with a slight excess of hydro-
d. On boiling the liquid, the ethal and the fatty acids of the soap rise to
e, in the form of an oily layer, which is separated by decantation, and
a second time in the same manner, to decompose a small remaining quantity
ceti; the fatty acids are again separated by means of hydrochloric acid, and
with slaked lime added in excess. A mixture of lime-soap and hydrate of
is obtained, from which the latter is dissolved out by alcohol. Lastly, the
distilled off, and the cetylic alcohol which remains is purified by crystallisa-
ether. Heintz boils spermaceti with an alcoholic solution of potash; preci-
boiling liquor with a concentrated aqueous solution of chloride of barium;
ves out the ethal from the precipitate with alcohol. As the alcohol also dis-
ll quantities of barium-salts, it is removed by distillation, and the ethal
ains is dissolved in cold ether, and finally purified by several crystallisations
.

alcohol or ethal is a white solid crystalline mass, which melts at a tempera-
48° C., but solidifies at 48° (Chevreul). It melts in water at 50° C., and
lidifies, the temperature rises to 51·5°; when melted alone, it solidifies at
5° (Heintz). When slowly cooled, it crystallises in shining laminæ: it
llises on cooling from solution in alcohol. It is without taste or smell, and
hout alteration, passing over even with vapour of water. It is insoluble in
mixes in all proportions with alcohol and ether.

es not give off water when heated with *oxide of lead*. It is not dissolved
alkalis; but when strongly heated with *potash-lime*, it gives off hydrogen,
verted into a potassium-salt, probably palmitate or ethalate (Dumas and
. Ch. Phys. [2] lxxiii. 124):

$$C^{16}H^{34}O + KHO = C^{16}H^{31}KO^2 + 4H.$$

decomposed by *sodium*, yielding *cetylate of sodium*, $C^{16}H^{33}KO$. With *potash*
de of carbon it forms cetyl-xanthate of potassium, $C^{16}H^{33}.K.COS^2$. Distilled
chloride of phosphorus, it forms chloride of cetyl, oxychloride of phosphorus,
hloric acid:

$$C^{16}H^{33}.H.O + PCl^3.Cl^2 = C^{16}H^{33}Cl + PCl^3O + HCl.$$

e and *phosphorus*, it yields iodide of cetyl. With strong *sulphuric acid*, it
-sulphuric acid, $C^{16}H^{33}.H.SO^4$.

(*loc. cit.*) regards ethal, not as a simple alcohol, but as a mixture of cetylic
alcohols, $C^{16}H^{34}O$, and $C^{18}H^{38}O$: because, according to his experiments,
acid of Dumas and Stas, is a mixture of palmitic and stearic acids, sepa-
lution in boiling alcohol and precipitation by acetate of barium.

, IODIDE OF, $C^{16}H^{33}I$. (Fridau, Ann. Ch. Pharm. lxxxiii. 9).—Pre-
ntroducing phosphorus into cetylic alcohol heated to 120° C. in an oil-bath,
an excess of iodine by small portions at a time, while the mixture is con-
rred. Hydriodic acid is then given off, together with phosphorous acid, while
phosphorus crystallises out, and iodide of cetyl remains in the liquid state.
reaction is complete, the iodide of cetyl is decanted, washed with cold
ch causes it to solidify, and then crystallised from alcohol. It crystallises
s interlaced laminæ, insoluble in water, easily soluble in ether, more soluble
than in cold alcohol. Melts at 22° C., and solidifies on cooling in rosettes
atty aspect. Burns with a clear flame, giving off free iodine.

not distil without alteration, but decomposes quickly at 250° C., giving off
pours of iodine and hydriodic acid, together with an oily hydrocarbon. It is

violently attacked by *mercuric* oxide at 200°, yielding an oil (cetene?) t iodide of mercury and metallic mercury, and leaving a crystallisable solid f With oxide of silver recently precipitated, and still moist, it forms the sar melting at 50°. With cetylate of sodium it yields iodide of sodium and o

$$C^{16}H^{33}.K.O + C^{16}H^{33}.I = KI + (C^{16}H^{33})^2O.$$

Ammonia in solution does not act on iodide of cetyl, but gaseous amm it into tricetylamine, $N(C^{16}H^{33})^3$. With phenylamine it forms cetyl-phe dicetyl-phenylamine. (Fridau).

CETYL, NITRIDE OF. See CETYLAMINE.

CETYL, OXIDE OF. *Cetylic ether.* $(C^{16}H^{33})^2O$.—Obtained by treati sodium, $C^{16}H^{33}KO$, with iodide of cetyl at 110° C., washing the product water to remove iodide of potassium, and crystallising from alcohol crystallises in shining scales. Melts at 55° C., and solidifies between 5 a radiated mass; distils at 300° for the most part without decompositi attacked by hydrochloric or nitro-hydrochloric acid at the boiling heat. b phuric acid destroys it. (Fridau, Ann. Ch. Pharm. lxxxiii. 20.)

Cetyl-ethyl-oxide or *cetylate of ethyl*, $C^2H^5.C^{16}H^{33}.O$, and *cetyl-amyl-ox of amyl*, $C^5H^{11}.C^{16}H^{33}.O$, are obtained in like manner by treating cetyla with iodide of ethyl or amyl. They both crystallise in laminæ, solul or ether: the ethyl-compound melts at 20° C., the amyl-compound at 30°. Ann. Ch. Pharm. cii. 220.)

Cetyl-sodium-oxide or *cetylate of sodium*, $C^{16}H^{33}NaO$, obtained by sodium or cetylic alcohol, is a greyish-yellow solid which begins to melt a is perfectly fluid and transparent at 110°. It is not decomposed by boili hydrochloric acid separates cetylic alcohol from it. (Fridau.)

CETYL, STEARATE OF. $C^{34}H^{68}O^2 = C^{18}H^{35}O.C^{16}H^{33}.O$.—Pre butyrate. Thin white shining laminæ, sparingly soluble in boiling al cold ether, easily in boiling ether. Melts at 55°—60° C., and forms a cr on cooling. Volatilises with partial decomposition when heated in a tub

CETYL, SUCCINATE OF. $C^{36}H^{70}O^4 = (C^4H^4O^2)''.(C^{16}H^{33})^2.O^2$.— heating 1 at. succinic acid with 2 at. cetylic alcohol in an air-bath, neu carbonate of sodium and recrystallising from ether. White laminæ, spa in alcohol, more freely in ether-alcohol, still more in pure ether. *loc. cit.*)

CETYL, SULPHATE (ACID) OF. *Cetylsulphuric acid. Sul*

$C^{16}H^{34}SO^4 = \left.\begin{matrix}(SO^2)'' \\ C^{16}H^{33}.H\end{matrix}\right\}O^2$.—Produced by mixing sulphuric acid with c at the temperature of the water-bath (Dumas and Péligot, *loc. cit.*) Köhler (*loc. cit.*) and Heintz (*loc. cit.*) the most abundant product i mixing the two substances at the lowest temperature at which they w the melting point of cetylic alcohol; dissolving the mixture in alcohol a with potash; separating the precipitate from the liquid; concentratin treating the residue with ether, which extracts undecomposed cetylic leaves cetylsulphate of potassium; and repeatedly crystallising the latte alcohol.

Cetylsulphate of potassium forms white nacreous laminæ, consisting microscopic needles; it is moderately soluble in hot alcohol, less in boili soluble in ether. It is not fusible. Heated to 140° C. with cyanide of yields cyanide of cetyl.

CETYL, SULPHIDE OF. $(C^{16}H^{33})^2S$.—Prepared by the actio of cetyl on an alcoholic solution of monosulphide of potassium at the Chloride of potassium then forms and sulphide of cetyl rises to the s liquid, where it solidifies on cooling. It is then washed with cold wat boiling water, and repeatedly crystallised from a mixture of alcohol and melting point becomes fixed at 57·5° C. It forms shining scales resemb cetylic mercaptan. It dissolves readily in ether, and in boiling alcohol, in cold alcohol. The alcoholic solution forms a white precipitate wi lead, also dissolved in alcohol. (Fridau, Ann. Ch. Pharm. lxxxiii. 16.)

CETYL, SULPHYDRATE OF. *Cetylic Mercaptan.* $C^{16}H^{33}.H.S$ by treating sulphydrate of potassium dissolved in alcohol with an alcohol chloride of cetyl. The product contains a certain quantity of sulphide of purified by adding acetate of lead, then water, washing with water, and ether, which dissolves the cetylic mercaptan and deposits it on evaporati line scales having a silvery lustre. It melts at 50·5°C., but solidifies ag cooled down below 44°, assuming the form of interlaced dendrites. It old alcohol, easily in ether, somewhat less easily in boiling alcohol. When water it gives off a peculiar odour.

alcoholic solution produces, after a while, white flocculent precipitates with ic solutions of silver-salts and of mercuric chloride; it does not precipitate f lead, platinum or gold. Mercuric oxide does not act sensibly upon it, h temperatures. (Fridau, Ann. Ch. Pharm. lxxxiii. 18.)

AMINES. Bases formed by the substitution of one or more atoms of ce of hydrogen in a molecule of ammonia. *Mono-* and *di-cetylamine* are

lamine or *Nitride of Cetyl.* $C^{48}H^{99}N = N(C^{16}H^{33})^3$. — This base is produced ammonia-gas into iodide of cetyl heated to 150° C. A white precipitate f ammonium is then formed, increasing in quantity if the temperature be for a while at 180°, and the substance which remains in the fused state is ne. It dissolves in boiling alcohol and crystallises in colourless needles, ° C. and solidifies in mammellated crystals on cooling.

of tricetylamine are insoluble in water, but soluble in ether and alcohol, n the hot liquids. The *hydrochlorate*, $C^{48}H^{99}N.HCl$, crystallises from boiling eedles, which are less fusible but more soluble than the base itself. Potash he boiling solution separates tricetylamine in the form of a heavy oil. *latinate*, $2(C^{48}H^{99}N.HCl).PtCl^4$, is a cream-coloured, almost pulverulent insoluble in water, sparingly soluble in alcohol. (Fridau, Ann. Ch. xiii. 25.)

nylamine, $N.H.C^{16}H^{33}.C^6H^5$, and *Dicetylphenylamine*, $N.(C^{16}H^{33})^2.C^6H^5$, are y the action of iodide of cetyl on phenylamine (*q. v.*)

-XANTHIC ACID. $C^{17}H^{34}OS^2 = \left.\begin{matrix}(CO)''\\ C^{16}H^{33}.H\end{matrix}\right\}S^2$.—This acid is known only ium-salt, which is prepared by adding alcohol and hydrate of potassium to solution of cetylic alcohol in sulphide of carbon, heating the mixture a the boiling point of alcohol, then leaving it to itself for a while and The clear solution, on cooling, deposits light scales, which may be purified with a small quantity of cold alcohol and dissolving in boiling alcohol.

is white, tasteless, odourless, very hygroscopic and unstable. Its alcoholic ves a white precipitate with *mercuric chloride;* canary-yellow with nitrate lackening in a few minutes; white with acetate of *lead*, also blackening hite gelatinous with salts of *zinc*. Digested with hydrochloric acid, it yields hol. (Desains and De La Provostaye, Ann. Ch. Phys. [3] vi. 494.)

DIC ACID. An acid existing in the seed of sabadilla (*Veratrum Saba-*, and probably also in the root of white hellebore (*Veratrum album*), and *m autumnale.* To prepare it, the oil extracted from sabadilla seeds by onified with potash; the soap decomposed by tartaric acid; the mixture he distillate neutralised with baryta; and the resulting barium-salt eva- dryness, and distilled with syrupy phosphoric acid. Cevadic acid then n white nacreous needles. It is soluble in water, alchohol, and ether, and butyric acid; melts at 20° C. and sublimes at a temperature a few degrees s salts have a peculiar odour. The ammonium-salt gives a white precipitate salts.

DIN or **HORDEIN.** A mixture of starch, cellulose, and azotised matter om barley.

ANITE or **CEYLONITE.** A ferruginous variety of spinel (Al^2MgO^2), on, and other localities, having the magnesium more or less replaced by and the aluminium by ferricum. It is the *pleonast* of Haüy. (See Spinel.)

ASITE. A mineral belonging to the zeolite family, and consisting es- f hydrated silicate of aluminium and calcium, a certain portion of the eing however always replaced by potassium or sodium. It crystallises in onging to the hexagonal system. Primary form, an obtuse rhombohedron, angle of the terminal edges = 94° 46′. It occurs in the primary form, and bination R . $-\frac{1}{2}$R . $-$2R. Ratio of principal to secondary axes = 1·086. istinct parallel to R. Specific gravity 2·0 to 2·1. Hardness 4—4·5. Trans- d colourless, sometimes flesh-red, with vitreous lustre. Streak uncoloured. neven. Brittle. Shrinks before the blowpipe to a blistered, slightly trans- mel. It is perfectly decomposed when heated in the state of powder before pe. It occurs in scattered crystals in the fissures of some trap rocks, and ows of certain geodes disseminated in the same rocks.

position of most varieties of chabasite is nearly represented by the formula $^3.4SiO^2 + 6aq.$, which (if $al'' = \frac{2}{3}$ Al), may be reduced to that of a meta- $''(al'')^2Si^4O^{12} + 6aq$. Sometimes, however, the amount of alkali is consider-

able, as in the fourth of the following examples, which approache
$\left.\begin{matrix}Ca\frac{1}{2}\\Na\end{matrix}\right\}(al'')^2Si^4O^{12} + 6aq.$

Analysis *a* is of a specimen from Kilmalcolm in Renfrewshire, by Thom
Aussig in Bohemia, by Rammelsberg; *c*, from Annerode near Giessen
d, from Port Rush in Ireland, by Thomson:

	SiO^2	Al^2O^3	Fe^2O^3	$Ca''O$	Na^2O	K^2O	H^2O
a . .	48·75	17·44	—	10·47	—	1·45	21·7
b . .	47·91	18·14	—	9·64	0·25	2·56	21·5
c . .	47·00	19·71	0·15	10·63	0·65	0·33	22·2
d . .	48·99	19·77	0·40	4·07	6·07	—	20·7

Sometimes, however, the proportion of silica is somewhat greater, an
position is more nearly represented by the formula $2(Ca''O.Al^2O^3).5Si$
$(Ca''al^3H^2)Si^9O^{27} + 11aq.$; and here again, the proportion of alkali-metal
siderable, as in the variety called *acadiolite*, which may be represented by
$(Ca^{\frac{1}{5}}Na^{\frac{2}{5}}K^{\frac{1}{5}})^4al^6H^2Si^9O^{27} + 11aq.$ Analysis *e* is chasabite from Drottn
near Gustassberg in Jemtland (Berzelius); *f* is *acadiolite*, from Ne
(Hayes):

	SiO^2	Al^2O^3	$Ca''O$	Na^2O	K^2O	H^2O
e . .	50·65	17·90	9·37	—	1·70	19·90 =
f . .	52·02	17·88	4·24	4·07	3·03	18·30 =

(*Rammelsberg's Mineralchem*

According to Dana, *Haydenite* from Jones' Falls in Maryland, is merely a
variety of chabasite crystallised in scalenohedrons.—*Phacolite* from Leipa i
another mineral of similar constitution, but containing less water, viz. (M
+ 9aq.

CHÆROPHYLLUM. The fleshy root of *Chærophyllum bulbosum*,
coming into use in France as an article of food, has been examined by Pa
rend. xliii. 269), and compared with that of the potato (a yellow variety)

	Chærophyllum.
Water	63·618
Starch, &c.	28·634
Cane-sugar	1·200
Albumen and other nitrogenous substances .	2·600
Fat	0·348
Inorganic matters	1·500
Cellulose and pectin-substances . . .	2·100

The comparison is evidently to the advantage of the chærophyllum.
Polstorf (N. Arch. Pharm. v. Brandes, xviii. 176), the seeds of this p
an alkaloïd, *chærophylline*. Most species of chærophyllum are aromatic.

CHAILLETIA TOXICARIA. An ulmaceous plant possessing poi

CHALCANTHITE. Native sulphate of copper. (See SULPHATES.)

CHALCEDONY or *Calcedony*.—A variety of quartz exhibiting vario
white, yellow, grey, brown, green, and blue. It has usually the subdued l
and is transparent or translucent, some milk-white varieties being opaque.
mammillary and botryoïdal shapes, and as stalactites in cavities roofed or
According to Fuchs, it is true quartz with some opal disseminated thro
rieties of chalcedony are: agate, carnelian, cat's eye, chrysoprase, flin
onyx, plasma, and sand (*q. v.*) Common chalcedony occurs in the toadsto
shire, in the trap rocks of Fifeshire, the Pentland Hills, and the Hebrides
specimens also in Trevascus Mine in Cornwall, in Iceland, and in the Far

CHALCODITE. A hydrated magnesio-ferrous silicate found near
Jefferson county, New York, and originally mistaken for cacoxene.
stellate globular masses, having a bronze-like aspect, or as a deposit upo
tite; also in prisms with very distinct cleavage in one direction.
yellowish-brown to blackish-green, with somewhat lighter streak. Lustre
on the cleavage faces, metallic and nacreous. Very flexible in thin lamin
1 to 1·5. Before the blowpipe, it gives off water, and exhibits the react
Hydrochloric acid does not act upon it in the cold, but when heated, d
with separation of silica. (C. U. Shepard, Sill. Am. J. [2] xiv. 265.)

CHALCOLITE. See URANITE.

CHALCOPHACITE. Octahedral arsenate of copper. (See LIROCO

COPHYLLITE. Syn. with Copper-mica.

COPYRITE. Syn. with Copper-pyrites.

COSTIBITE. Native sulphantimonite of copper. (See Wolfsbergite.)

COTRICHITE. Native cuprous oxide. (See Copper, Oxides of.)

LITE. This name is applied to two minerals found imbedded in grey
ne, from the county of Antrim in Ireland. One of these minerals is
with conchöidal fracture; cream-coloured, with faint waxy lustre; trans-
he edges, with faint lustre on the streak; slightly unctuous to the touch,
ng to the tongue. In water, it falls to pieces with decrepitating noise. It
sed by hydrochloric acid, with separation of pulverulent silica.
g to v. Hauer (Wien Acad. Ber. xii. 229) it contains

SiO^2	Al^2O^3	$Fe''O$	$Ca''O$	$Mg''O$	H^2O	Total.
44·11	10·90	1·05	6·74	13·01	24·07	= 99·88

s of manganese and potassium, whence the formula: $4M''O.Al^2O^3.6SiO^2 +$

er mineral (first analysed by Thomson) is a dense aggregate of concen-
rous spherules, of pale blood-red colour; glistening; translucent on the edges;
s 5, and specific gravity 2·24. It does not fall to pieces in water, and when
d by hydrochloric acid, yields a jelly of silica.
neral, analysed by v. Hauer (Wien Acad. Ber. xi. 18), gave:

SiO^2	Al^2O^3	$Fe''O^3$	$Ca''O$	$Mg''O$	Loss by ignition.	Total.
8·26	27·71	trace	12·01	6·85	14·32	= 99·15

e formula $6M''O.4Al^2O^3.9SiO^2 + 12H^2O$ (Kenngott, Jahresber. f. Chem.
ii. 842). Both minerals are orthosilicates, the formula of the first being
o $(M'')^4(al'')^2H^{10}Si^6O^{24} + 7aq.$ which is of the form $6R^4SiO^4 + 7aq.$, and that of
to $(M'')^2(al'')^4Si^3O^{12} + 4aq.$ or $3R^4SiO^4 + 4aq.$

K. Friable carbonate of calcium, very abundant, and forming the upper
the cretaceous group which occupies nearly the whole of the south-eastern
gland, and a considerable portion of the north of France. It is white and
ry soft, and without the least appearance of polish in its fracture. Specific
to 2·6. It contains about 2 per cent. of clay, besides free silica. Some
perhaps most, contain a little iron. Sometimes also magnesia and chloride
occur in small quantities. It may be purified by trituration and elutria-
ferruginous and siliceous particles subsiding first, while the pure chalk
emain suspended: this purified chalk when dried is called *whiting*. Chalk
vely used in agriculture, as an addition to soils which are deficient in

ne *chalk* is also occasionally applied to other earthy minerals; thus *Black*
peculiar kind of slate, also called *Drawing slate*, which produces a black
eak on paper, and is used in crayon drawing. *Red chalk* is a clay, coloured
f iron.

K STONES. Gouty concretions in the joints, so called from their resem-
halk. They consist mainly of uric acid.

KOSINE. Syn. with Copper-glance.

YBEATE WATERS. Mineral waters containing carbonate of iron dis-
xcess of carbonic acid (p. 785).

YBITE. Native carbonate of iron (p. 784).

ELEON MINERAL. Manganate of potassium. (See Manganates.)

ÆROPS HUMILIS. The leaves of this palm are coated with wax,
y alcohol into cerin and myricin. (Teschemacher, *Rochleder's Phytochemie*,

OISITE. A black earthy mineral from Chamoisin in the Valais, contain-
ing to Berthier (Ann. Min. v. 393), 14·3 per cent. silica, 60·5 ferrous
alumina, and 17·4 water (=100), with 15 per cent. of carbonate of calcium.
ps a mixture of magnetic iron ore with a hydrated silicate of aluminium.

OTTE. A mixture of fire-clay and fragments of burnt pottery used for
e-bricks, pipes, crucibles, &c. *Chamotte-stones* from the kaolin of Halle,
by Wackenroder (Arch. Pharm. [2] lxxv. 27), to contain 85·00 per cent.
3 alumina, 2·23 ferric oxide, and a trace of magnesia; loss by ignition 1·00.

PAGNE WINE is made from selected grapes, red and white, the must
after fermenting in the vats from 12 to 15 hours, is drawn clear off into the
s racked off about Christmas, once more after four weeks, and then fined with

isinglass, which treatment is also repeated. The new wine is put into
the month of May, leaving about 2 inches empty under the corks, w
down; and the bottles are laid on their sides for the progress of the
from 6 to 10 per cent. of the bottles burst. This stage of the proces
in September, when the bottles are placed on their mouths, and left so fo
to let the sediment settle in the neck, which settlement is promoted by
ing. By dexterous opening of the bottles, the muddy deposit is discha
are then filled up with clear wine, corked afresh, and packed up for tran
being covered either with melted resin, wax, or tin-foil. In seaso
when the must is not sweet enough, sugar is added by pouring a thimb
(called *liquor*), into each bottle, the wine destined for Russia rece
dose.

A like procedure is followed in making the sparkling wines of Germ
Moselle, and at Esslingen in Wurtemburg. Carbonic acid gas is freque
by an air-pump into the other more or less factitious frothing wines
Germany.

CHANTONITE. A mineral said to exist in certain meteorites (

CHARA FŒTIDA. The ash of this plant has been analysed by S
(Pogg. Ann. lxxxiv. 80). Two specimens of the dried plant yielded
per cent. of ash, the chief characteristic of which was the very large q
which it contained, viz. 42·7 per cent., which exists in it almost entirel
carbonate. The water in which the plant grew yielded in 100 pts. 0·1
matter, of which 0·104 consisted of carbonate of calcium.

CHARCOAL. See Carbon (p. 759); also *Ure's Dictionary of*
tures and Mines, i. 615).

CHATHAMITE. Native arsenide of cobalt. (See Cobalt.)

CHAVICA OFFICINARUM. One of the names of the plan
long pepper. (See Pepper.)

CHAY or **CHAYA ROOT.** The root of the *Oldenlandia umbellat*
wild on the coast of Coromandel, and is likewise cultivated there for t
and calico-printers. It is used for the same purposes as madder, to
to be far superior, giving the beautiful red so much admired in the Madr

CHEESE is formed from milk by coagulating it with rennet; sepa
from the whey; compressing the curd in moulds, after it is duly seas
and keeping this solidified milk in a cool place for some time, to allow
a kind of fermentation, by which it acquires the flavour and other w
perties of cheese. The chemical changes undergone by the casein
are little understood. The milk, before it is coagulated, should be he
85° F.; then it receives the rennet—the infusion in water of the sto
born calf, commonly salted and dried to make it keep. The rennet effe
completely in about an hour and a half. The curd is cut with a three
drained of its whey; broken down by hand or otherwise, subjected t
then comminuted more completely; put into its mould; and exposed
pressure, commonly under a heavy weight, but in large dairies by a scre
can be progressively tightened. The comminuted curd may be well
closing it in linen cloth and immersing it for one day or several days
then drained, wiped, and set away in a cold room. Roquefort cheese
mixture of sheep and goats' milk, and is ripened in a chamber or
very low temperature.

The following table exhibits the composition of several kinds of c
mined by Payen (J. Pharm. [3] xvi. 279).

Composition of Cheese.

	Water in 100 pts.	Ash in 100 pts. of substance:		Nitrogen in 100 pts. of substance:		
		normal.	dry.	normal.	dry.	ash-free
Cheese from Chester	30·39	4·78	6·88	5·56	8·00	8·59
" Brie	53·99	5·63	12·08	2·39	5·14	5·85
" Neufchatel	61·87	4·25	11·17	2·28	5·99	6·07
" Marolles	40·07	5·93	9·91	3·73	9·24	6·92
" Roquefort	26·53	4·45	6·06	5·07	6·91	7·35
" Holland	41·41	6·21	10·61	4·10	7·01	7·84
" Gruyères	32·05	4·79	7·05	5·40	7·96	8·59
" Parmesano	30·31	7·09	10·16	5·48	7·87	8·76

of two samples of cheese has been analysed by **Johnson** (Ann. Ch. Pharm. 9): *a.* Hand-cheese (*Hand-Käse*) from the neighbourhood of Giessen; eese.

Na^2O	CaO	MgO	Fe^2O^3	CO^2	P^2O^5	$NaCl$	
7·33	2·55	—	0·11	0·03	13·68	72·47	= 101·02
3·67	17·82	0·81	0·17	0·08	20·45	55·37	= 100·83

d-cheese exhibited an alkaline reaction; gave off 46·35 per cent. water at e dried substance yielded 12·86 per cent. nitrogen and 13·15 per cent. ash. cheese yielded 44·70 per cent. water, and, after drying, 8·0 per cent. nitrogen per cent. ash.

reparation of cheese, see *Traité de Chimie générale, par Pelouze et Frémy,* 213, and *Muspratt's Chemistry*, article CHEESE.

ANTHUS CHEIRI. *Wallflower.*—The fragrant flowers of this plant tter taste like that of cress. They contain a substance which assumes a lour in contact with sulphuric acid. The seeds contain myrosin, but no id. (*Rochleder's Phytochemie*, p. 98.)

RYTHRINE. An alkaloïd existing in very small quantity in *Chelido- s* (**Probst**, Ann. Ch. Pharm. xxix. 120; xxxi. 250). It forms orange-red according to **Schiel** (Sill. Am. J. [2] xx. 220), is identical with sangui- $H^{16}O^4$, the alkaloïd of *Sanguinaria canadensis.* (See SANGUINARINE.)

DONIC ACID. $C^7H^4O^6 = \left.\begin{matrix}C^7HO^3\\H^3\end{matrix}\right\}O^3$. (**Probst.** Ann. Ch. Pharm. xxix. ch, *ibid.* lvii. 273.—**Hutstein,** N. Br. Arch. lxv. 23.—Gm. xii. 413.— 754).—This acid exists in all parts of *Chelidonium majus*, the common in the form of a calcium-salt, together with malic acid and another acid, maric: it is most abundant at the flowering time. To obtain it, the ex- ce is coagulated by heat and filtered. The filtrate is acidulated with nitric itrate of lead is added in small quantities, as long as a crystalline precipitate being taken not to add too much either of the acid or of the lead-salt. The which contains lime, is diffused in a large quantity of water and decomposed etted hydrogen, which takes place slowly; the solution of acid chelidonate is neutralised with chalk and boiled with animal charcoal; and the neutral aporated till saline crusts form. After cooling, white crystals are obtained, lustre, which are to be purified by repeated crystallisation. To separate e chelidonate of calcium thus obtained is dissolved in water, the solution d with carbonate of ammonia, and the concentrated solution of chelidonate um mixed with twice its volume of moderately dilute hydrochloric acid. acid is then precipitated as a mass of crystalline needles, which are to be a filter, washed, and purified by crystallisation from hot water.

ic acid thus prepared contains 2 at. water of crystallisation, $C^7H^4O^6.2H^2O$, ives off (amounting to 9·2 per cent.) at 100° C., or when left over oil of y spontaneous evaporation it may be obtained in long needles containing r (12·7 per cent.). It dissolves sparingly in cold, more freely in boiling solution solidifying as it cools. According to **Probst**, it requires for 6 pts. of water at 6° C. and 26 pts. at 100°. It dissolves in hydrochloric ric acids more abundantly than in water, and in 700 pts. of 75 per cent. 12° C.

d dried at 100° C. gives off 2·0 per cent. (½ at.) water at 150°, probably l decomposition. If the heat be continued, no further loss takes place 10°; but at that temperature the acid sustains a considerable though not le loss; between 220° and 225° decomposition takes place, the residue oft, blackening, and giving off carbonic anhydride. The black mass, treated r, yields an acid which crystallises in yellowish crusts. Chelidonic acid slight detonation when heated in the air. It is scarcely attacked by strong : but moderately dilute nitric converts it, with evolution of nitric oxide ic anhydride, into another acid; malic acid does not appear to be formed. acid dissolves without decomposition in cold oil of vitriol; but on the appli- eat, the solution becomes yellowish, and gives off gas-bubbles, assumes a -red colour at the boiling heat, but after long boiling, gives off sulphurous quires a dull undefinable colour. When the calcium-salt is boiled with lic acid is produced. (**Lerch.**)

NATES.—Chelidonic acid is a strong acid, dissolving zinc and iron, with evo- hydrogen, and decomposing carbonates. It is tribasic, and forms three

alts, viz. $C^7HM^3O^6$ or $C^{14}H^2\overset{\prime\prime}{M}{}^3O^{12}$; $C^7H^2M^2O^6$ or $C^7H^2M''O^6$; and $C^7H^3MO^6$ O^{12}; besides a few acid salts containing $C^7H^3MO^6.C^7H^4O^6$.

The *dimetallic* chelidonates are formed when the aci
oxide or a carbonate; with alkalis or their carbonates,
Most of the dimetallic salts are soluble in water a
several atoms of water, which are given off at or abov
silver-salts, however, become anhydrous at 100°.
bases are themselves colourless. They have no action
salts are produced by heating the dimetallic salts with
chelidonic acid or a dilute mineral acid. If the acid
duced. The monometallic salts are resolved by repeat
dimetallic salts. The *trimetallic* salts are formed by t
a caustic alkali or alkaline carbonate. Those which
fine lemon-yellow colour; those which are soluble imp
Most of them contain several atoms of water, which ar
have no reaction upon litmus. They are decomposed b
those of the alkali-metals absorb carbonic acid from
chelidonate and a carbonate.

The *acid* chelidonates crystallise from the solution
hydrochloric acid, in delicate needles or scales, whic
crystallisation at 100° C. They redden litmus, and m
their base when repeatedly treated with hydrochloric

Chelidonate of Ammonium. $C^7H^2(NH^4)^2O^6$.—
dicalcic salt neutralised with carbonate of ammonium, fi
ammonium-salt, on cooling, in snow-white silky needle
spontaneous evaporation, ultimately solidifies to a tra
lected and drained on a filter, yields the ammonium-s
sembling a knot of the finest silver-white hair. It eff
gives off 14·23 per cent. (2 at.) water at 100° C., and
of quinine. (Lerch.) It does not give off ammon
air at ordinary temperatures, or when heated to 100°.
brownish and gives off carbonate off ammonium; the re
acid. By repeatedly evaporating the solution and
converted into the acid salt. It does not form a trim
carbonate of ammonium or caustic ammonia. (Lerch

Chelidonates of Barium.—The *tribarytic salt,*
obtained by mixing a hot solution of the monobarytic
with chloride of barium, and quickly washing the p
lemon-yellow powder which does not give off water a
acid from the air, dissolves sparingly in water, not at

The *monobarytic salt*, $C^7H^2Ba''O^6 + aq.$, is obtained by
calcium-salt with a soluble barium-salt, or by neut
baryta or its carbonate. It is colourless, crystallin
water.

The *acid salt*, $C^{14}H^6Ba''O^{12}.2C^7H^4O^6 + 4aq.$, is produc
salt in boiling hydrochloric acid.

Chelidonates of Calcium.—The *tricalcic salt*,
is prepared by boiling the monocalcic salt with ammonia,
salt mixed with ammonia with chloride of calcium. It
very little soluble in water, insoluble in alcohol.

The *monocalcic salt*, $C^7H^2Ca''O^6 + 3aq.$ (at 100°), occur
It crystallises in silky prismatic needles, very little sol
boiling water; insoluble in absolute alcohol. The solut
salt is not efflorescent, and does not part with its water

The *acid salt*, $C^{14}H^6Ba''O^{12}.2C^7H^8O^6 + 4aq.$, obtained
with hydrochloric acid, crystallises in needles.

Chelidonate of Copper.—Green sparingly solub
rating a mixture of an alkaline chelidonate with sulpha

Chelidonates of Iron.—The aqueous acid dissol
donate.

Ferric Chelidonate. $Fe^2O^3.C^{14}H^4O^{10}$.—The solution
to a higher degree of oxidation during evaporation, an
cipitate. The disodic salt forms with aqueous sesquic
precipitate, somewhat soluble in acetic acid and in exc
does not diminish in weight at 100° C., and if set on
with a sparkling light, leaving charcoal and sesquioxid

When chelidonate of potassium is mixed with exces
greater part of the ferric chelidonate remains diss

assumes a darker colour, and ultimately becomes black-brown and opaque, rs its pale yellow colour after some time; on heating the liquid, the changes take place more quickly. The dark brown liquid forms with ammonia a vn precipitate, which becomes black when treated with a larger quantity of probably from formation of protoxide of iron.

onates of Lead.—A *basic salt*, $C^{14}H^2Pb^3O^{12}.3Pb''O$, is obtained by adding nbic salt mixed with ammonia to basic acetate of lead.

olumbic salt, $C^{14}H^2Pb^3O^{12}$, is produced by treating the diplumbic salt with or by mixing a cold solution of dicalcic chelidonate with basic acetate of llowish-white flakes are then deposited containing 3 at. water ($C^{14}H^2Pb^3O^{12}$. nich is given off between 150° and 160° C., the salt then turning yellow. If ns are mixed at the boiling heat, the anhydrous salt is produced at once in f a lemon-yellow precipitate, darker in colour if mixed with the preceding. orised and decomposed by acids. Insoluble in water and in alcohol, soluble ts.

soplumbic salt, $C^7H^2Pb''O^6$ + aq., is deposited, on mixing the monocalcic salt with lead, in small shining crystalline scales or slender needles, which are insoter, soluble in lead-salts and in ordinary strong nitric acid, but not in fuming .

onate of Magnesium.—Efflorescent needles, obtained by neutralising the us acid with carbonate of magnesium.

onates of Potassium.—The *tripotassic salt* is deposited in yellow crys- solution of the dipotassic salt mixed with caustic potash. It has no alkaline hen pure, but absorbs carbonic acid from the air, and is converted into the dipotassic salt. Boiled with excess of caustic potash, it yields oxalate of

otassic salt is obtained by decomposing the dicalcic salt with carbonate of

lonate of calcium and potassium, $C^7HKCa''O^6$, is obtained by mixing a con- solution of the dicalcic salt with an equivalent quantity of carbonate of po- In a very dilute solution, the lime is immediately precipitated as carbonate.

onates of Silver.—The *triargentic salt*, $C^7HAg^3O^6$, is obtained by precipi- tricalcic or the dicalcic salt, mixed with ammonia, with nitrate of silver. It very unstable precipitate.

rgentic salt, $C^7H^2Ag^2O^6$, is produced by dissolving oxide of silver in cheli- l, or by precipitating the dicalcic salt with nitrate of silver and heating to g point. It then separates on cooling in long colourless needles resembling silver. It is permanent in the air at ordinary temperatures, and is not tween 100° and 200° C.; decomposes with slight detonation between 140° It dissolves in water, ammonia, and strong nitric acid, but not in alcohol.

ate of silver and calcium, $C^{14}H^2Ag^4Ca''O^{12}$, is obtained by mixing a concentrated al solution of the dicalcic salt with a concentrated solution of nitrate of silver, yellow precipitate, which alters but little in drying, and is decomposed by after long continued boiling.

onates of Sodium.—The *trisodic salt* has not been obtained in definite

odic salt, $C^7H^2Na^2O^6$ + 4aq., is prepared by decomposing the dicalcic salt nate of sodium; care must be taken not to add too large an excess of the ch would give rise to the simultaneous formation of trisodic chelidonate, and lic salt containing both calcium and sodium, a reaction which is immediately by the yellow colouring of the liquid.

odic salt is very soluble in water both hot and cold, and is difficult to crys- y slow evaporation, however, small prismatic needles are obtained, which lowly when exposed to air. They contain 21·16 per cent. water of crystal- f which 15·5 per cent. goes off, at 100° C., the rest between 150° and 160°.

nosodic salt, $C^7H^3NaO^6$ + 2aq., is obtained in slender needles by treating the t with chelidonic acid.

odic salt treated with boiling hydrochloric acid, yields slender needles or ich appear to consist of an *acid salt*, $C^7H^3NaO^6.C^7H^4O^6$ + 3aq.

onate of Strontium.—Slender needles obtained by dissolving the carbo- elidonic acid.

onate of Zinc.—Obtained by saturating the acid with oxide of zinc; it is , and has an acid reaction.

DONINE. $C^{20}H^{19}N^3O^3$ (?) (Godefroy, J. Pharm. Dec. 1824; Probst, Pharm. xxix. 123; Realing, *ibid.* 131; Will, *ibid.* xxxv. 113; Gerh. iv. alkaloïd contained in all parts of the *Chelidonium majus*, especially in the

root. It is obtained by exhausting the root with wat
acid, precipitating by ammonia, dissolving the precipit
sulphuric acid, reprecipitating by ammonia, and treat
which dissolves chelerythrine (sanguinarine) and leaves
product, it is dissolved in the smallest possible quantity
phuric acid; the solution is mixed with twice its volum
which, after a while, throws down a granular precipitate of
the precipitate is digested with ammoniacal water, which
and the base thus obtained is crystallised from strong alcoh

Chelidonine crystallises in small colourless tablets,
alcohol and ether. It melts at 130° C. to a colourless oil
temperature. The crystals contain 2 at. crystallisation-w
100° C. According to Will's analyses, the base dried at
cent. C, 5·6 hydrogen, and 12·2 nitrogen; the formula
5·4 H, 12·1 N, and 13·7 O. Water of crystallisation, by
culation 4·91.

Chelidonine dissolves readily in acids, forming salts
redden litmus. Its compounds with the weaker acids, s
posed by evaporation. Ammonia added to solutions of t
curdy precipitate, which after a while contracts into a gr
salts are likewise precipitated by tincture of galls.

According to Probst, solutions of chelidonine are not

Hydrochlorate of chelidonine is crystallisable, and diss
18° C. The *chloroplatinate*, $2(C^{20}H^{19}N^3O^3.HCl).PtCl^4$,
granular precipitate, yielding by analysis 17·42 and 1
formula requiring 17·77.

The *nitrate* is sparingly soluble in water; the *sulphate*
both in water and in alcohol: all three salts are crystallis

The *acetate* is obtained by decomposing the sulphate w
very soluble in water and alcohol, and dries up to a gumn

CHELIDONINIC ACID. $C^7H^{10}O^6$? (Zwenger,
—This is another acid contained in very small quantity i
the decoction of the plant acidulated with acetic acid, is
[or nitrate] of lead, chelidonic acid is precipitated, and
solution; and by treating the filtrate with basic acetate o
posing the precipitate with sulphuretted hydrogen, evapo
with ether, and again evaporating, chelidoninic acid is obt
yellow crystals. It dissolves easily in water, alcohol, an
the aqueous solution in hard, white, anhydrous crystals, h
rhomboïdal prism. It has a strongly acid taste, decompo
iron, with evolution of hydrogen. It melts at 195° C.;
tating. With *nitrate of silver*, it forms a white, crystal
pitate. *Nitric acid* converts the acid into oxalic acid. Z
chelidoninic acid the formula $C^{14}H^{11}O^{12}$; it may per
$2C^7H^{10}O^6.H^2O$.

CHELIDOXANTHIN. A yellow bitter substance
and flowers of *Chelidonium majus.* It is obtained by prec
acetate of lead, decomposing the precipitate with sulphure
ing the sulphide of lead with boiling water. It crystallis
more frequently forms a yellow friable mass. It is sparing
soluble in boiling water. The solutions are yellow and ve
either by acids or by alkalis. (Probst, *loc. cit.*)

CHEMICAL AFFINITY. *Chemical Attraction,*
traction, Elective Affinity; Chemische Kraft, Verwandts
Wahlanziehung; Affinitas, Attractio Electiva; Affinité.—Aff
of which bodies of dissimilar nature unite together to for
stitution, which cannot be destroyed by mechanical age
part, dissimilar in properties to the elements from which t
this force is of peculiar nature, distinct from all others, o
power which, under various circumstances, shows itself as
netism, mechanical force, &c., is a question still undecide
lated to heat and electricity, is manifest from the whole ra
indeed no chemical change can take place without a corresp
perature and electrical state of the bodies concerned. The
gress of discovery appears to tend, is that chemical actio
other manifestations of force result from certain movement
bodies, and are accordingly convertible into the other. Th

articles HEAT, LIGHT, and ELECTRICITY; for the present, while we are
henomena purely chemical, it will be convenient to speak of affinity as if it
ct force.

affinity and chemical combination are not used by all writers in exactly
se. L. Gmelin defines affinity as "the power by virtue of which bodies
nature combine together into a whole, which appears perfectly uniform to
ven when assisted by the most powerful instruments" (*Handbook*, i. 33).
he applies it to mixtures of liquids, as of alcohol and water, alcohol and
&c., and to solutions of solids in liquids, as of salts in water, resins in
as well as to combinations in definite proportion. Most chemists, how-
distinction between mixtures and solutions on the one hand, and com-
ed in definite proportions on the other, restricting the term "chemical
the force, whatever it may be, that is concerned in the formation of the
avour of Gmelin's view, it may be alleged that mixtures of liquids and so-
able chemical compounds, commonly so called, in these respects, that they
uniform in colour, density, refractive power, and other physical characters,
force which holds the heterogenous particles together in them is sufficient
tendency to separate arising from difference of density (*e. g.* a mixture of
lcohol, never separates into two layers, like oil and water), and can only be
the same means as are applied to the destruction of the more intimate kind
ons, viz. heat, or the superior affinity of another substance, as when resin
ed from its solution in alcohol by addition of water, or carbonate of potas-
s aqueous solution by alcohol.

, however, several well marked characters by which chemical combination
intimate kind, such as that of oxygen and hydrogen in water, hydrogen
in ammonia, sulphur and mercury in cinnabar, &c., is distinguished from
e or solution. These distinctions relate to the proportions in which the
of the compound are united, to the character of the compound, and to the
es attending its formation and decomposition.

ards *proportion.* Mixture and solution follow a law of continuity. Mis-
, such as alcohol and water, may be mixed in any proportions whatever,
dissolves in a liquid in all proportions, up to a certain limit, the point of
but chemical combination, properly so called, takes place in certain definite
and no others. Thus hydrogen and chlorine unite only in the ratio of 1 pt.
f hydrogen to 35·5 pts. of chlorine; oxygen and carbon, only in the ratio
bon to 8 and 16 pts. oxygen; nitrogen and oxygen, as 14 pts. nitrogen to
32 and 40 pts. oxygen; lead and oxygen as 103·5 lead to 8, 10⅔, and
en, mercury and sulphur as 100 mercury to 8 and 16 pts. sulphur, &c. &c.
indeed, the number of compounds formed by any two elements is definite,
ation never takes place in any intermediate proportions.

which regulates the proportions of the several compounds of the same two
lled the "Law of Multiples," and may be thus expressed: The several
in which two bodies, A and B, unite, may be represented by the formulæ
2B, A + 3B, . . . A + *n*B, or 2A + 3B, 2A + 5B, . . . 3A + 4B, . . . or in
+ *n*B; where *m* and *n* are integer numbers in most cases not exceeding 7, at
ganic compounds.* We have seen in the article ATOMIC WEIGHTS (p. 452),
the observation of these proportions which led Dalton to the idea of the
y. In short, if the ultimate atoms of the several elements be supposed to
ain invariable relative weights, and to unite and form chemical compounds
xtaposition, in the proportion of 1 : 1, 1 : 2, 2 : 3, &c., the law just enun-
s as a matter of course. It is possible that the distinction between true
mbination and mixture may be found in this: that combination takes
en ultimate atoms; mixture between the physical molecules of bodies, which
aggregates of atoms.

he *character of the product.*—The properties of a mixed liquid, as the colour,
c gravity, refracting power, &c., are always intermediate between those of
nts. In solutions also, the dissolved body imparts to the solvent its taste and
oportion to the quantity dissolved, the density of the solution also increasing
d continuously with the amount of solid matter taken up; but definite
npounds generally differ altogether in physical properties from their com-

---

ining proportions of the elements of organic compounds are regulated by much more
. In the series of fatty acids, for example, we find the same quantity of oxygen (8 pts.)
n 3, 2×3, 3×3, 4×3, 5×3, . . . 30×3 parts of carbon; and if, in addition to this, we con-
ous proportions of C, H, N, and O, existing in the numerous series of organic bodies, it
concluded that the constitution of these bodies would never have suggested the law of
bove stated. Indeed, it is only by introducing the hypothesis of compound radicles, that
on of organic bodies can be assimilated to that of inorganic compounds. (See ORGANIC
d RADICLES.)

ponents. Thus, with regard to *colour:* yellow sul
cinnabar; purple iodine and grey potassium yiel
purple iodine and grey lead form bright yellow iod
oxides bear no relation whatever to those of the me
of metals with chlorine, iodine, and other salt-ra
parent, though the metals themselves are opaque.
exhibiting an endless variety of colours, formed by
free state have no colour at all. The *density* of
mean between that of its constituents, being gener
and the *taste, smell, refracting power, fusibility,*
and electricity, and other physical properties, are
result from mere mixture of their components. I
that the physical properties of compounds are not
by any regular laws. Definite relations doubtless e
indeed, the regular gradations of boiling point, at
terms of homologous series of organic compounds,
still it is generally true that the properties of a
diate between those of its components, as in a mix

3. As to the *phenomena* which accompany the for
cal compounds, especially as regards *temperature.*
proportions, is always attended with evolution of
combustion, and decomposition is accompanied by
reduction of temperature; whereas the mere mix
change of temperature, and the solution of a solid
nature of combination, is attended with reduction
of the body from the solid to the liquid state. So
temperature attending the contact of a solid and
an indication of the formation of a definite compou
salts, such as chloride of calcium and sulphate of c
by contact with water, being at the same time
hydrates, in subsequently dissolving in the water, p
(See HEAT.)

The formation and resolution of chemical c
changes in the *electrical state* of their elements.
two elements produces any electrical disturbance,
account of peculiar difficulties in the investigation o
but the solution of a metal in an acid, which co
compound and the formation of another, calls in
force, which by certain arrangements, hereafter to
the form of an electric current. Conversely, an el
loped, whether by chemical action, or by friction,
of overcoming the most powerful chemical combin
travel through the circuit in opposite directions,
the circuit. No such effect is, however, produc
passage of an electric current through the soluti
its elements, but never causes it to separate from

For these reasons, we shall restrict the term CH
tion of compounds in definite proportion, and AFFI
in their production, and proceed to consider more
results of chemical combination and decomposition

Every elementary body is capable of uniting
with every other. It is true that some of the c
certain metals, of boron with silicon, selenium, a
carbon, have either not been formed or are but im
little doubt of the possibility of their formation. T
of the other non-metallic elements are least kno
manipulating with fluorine in the free state.

Compounds resulting from the union of two s
compounds of the first order; such are the metallic
chlorides of hydrogen, sulphur, phosphorus, &c.
uniting with each other in various ways like eleme
pounds containing three or four elements, which m
of the second order; such are double chlorides, K
sulphur-salts $K^2S.As^2S^2$; hydrated chlorides CaCl
pounds of the second order may be conceived as u
the third order, such as double salts, *e. g.* commo
potassium and sulphate of aluminium, $K^2O.SO^3 +$
power of combination does not appear to extend.

of the successive building up of chemical compounds in binary groups, *ualistic Theory* is, however, not the only one that can be taken, or indeed ccords best with the present state of knowledge. It is for many reasons ard all compounds, whether containing two, three, or more elements, as according to certain typical forms; for example, chlorides, iodides, bro-yanides, as formed on the type of hydrochloric acid HCl; acids, bases, ntaining oxygen or sulphur, seleniumn or tellurium, as formed on the er HH.O, &c. This is called the *Unitary Theory*. (See CLASSIFICATION, UBSTITUTION, TYPES, and the various articles in which particular com- described.) It is true, indeed, that compounds containing three or more y, in many instances, be formed by the direct union of binary compounds rder; thus double chlorides and iodides are formed by fusing together the imple chlorides, or by mixing their aqueous solutions and leaving them to sulphur-salts, such as $Na^2S.As^2S^3$, by fusing together the simple sulphides; also, in some instances, by heating together the so-called anhydrous e base; thus boric anhydride and magnesia fused together in the proper form borate of magnesium, $3Mg''O.B^2O^3$ or $Mg^3(BO^3)^2$; and anhydrous d in vapour of sulphuric anhydride, burns and forms sulphate of barium, $Ba''SO^4$. But it by no means follows that the arrangement of the atoms ing compound must be the same as in the simpler compounds from which ; thus, while the mode of formation of sulphate of barium just mentioned to the supposition that it is $Ba''O.SO^3$, other modes of formation, and reactions, indicate rather that its constitution is represented by the $.SO^4$ or $SO^2.Ba''.O^2$.

servations apply chiefly to inorganic compounds. Organic bodies, with n of cyanogen and the hydrocarbons, all contain at least three elements, listic view of the building up of compounds by pairs cannot be applied all, excepting on the supposition that they contain certain compound as *ethyl*, C^2H^5, *benzoyl*, C^7H^5O, &c., which play the same part as metals in mpounds, uniting like simple radicles, with oxygen, chlorine, bromine, &c. lp of these radicles, some of which have been obtained in the free state, ion of the best known organic compounds, such as the alcohols, ethers, cetones, and their derivatives, may be assimilated to that of inorganic and represented either on the unitary or the dualistic view.

Formation and Decomposition of Chemical Compounds.

al combination involves a total change in the arrangement of the atoms of g bodies, it is clear that cohesion, which tends to hold them in certain fixed ust be opposed to chemical union, and on the contrary, anything which gives he particles of the two bodies, and enables them to intermix and approach distances of each other, such as pulverisation, and more especially lique-t tend to promote it.

lly speaking, *one at least of the combining bodies must be either in the liquid eous state*, and if it be not so at ordinary temperatures, it must be brought te by elevation of temperature. Solid bodies either do not combine at combination is attended with great difficulty, because, from the immobility icles, their points of immediate contact are but few, and the exceedingly compound which may be formed at such points, acts as a partition to pre- contact and consequently further combination. But by continued rubbing, s the points of contact, more complete combination may often be effected: ner, finely divided copper may be made to combine with sulphur, the com-ng even attended with rise of temperature. If, on the other hand, the rmed by the two solids is itself fluid, its mobility gives rise to continu- contact, and combination goes on. Thus ice under 0° C. unites with chlo-m and other salts, and solid amalgam of lead with solid amalgam of bismuth. oxalic acid and lime may be made to combine by rubbing them together, acid contains more water of crystallisation than the oxalate of calcium able to take up: hence, at the beginning of the action, a little water is set solves the oxalic acid. In some cases it is sufficient to heat one of the till it softens: thus iron surrounded with charcoal and heated to white-y penetrated by the charcoal (*Cementation*). When, in consequence of one ies being in the fluid state, combination takes place at the ordinary tempera-tle above it, it is called *solution in the wet way* (*Solutio via humida*): if a erature is required, the process is called *solution in the dry way*, *fusion sicca*, *Confusio*).

f one or both of the bodies be in the fluid state, a higher temperature is ary to effect the combination.

Melted sulphur will not combine with carbon;
state of vapour into contact with red-hot charcoal,
might rather be expected to interfere with the
of sodium, in the efflorescent state absorbs carboni
and more quickly as it gets heated by the abs
violence. Charcoal requires to be heated before i
before it will combine with the oxygen. At ord
mixed with hydrogen and other inflammable gase
at a red heat, combination takes place immediately
and we might expect that heat, by increasing thei
favour the combination. The manner in which he
understood; but its effect is probably due to the in
it gives to the particles. (See HEAT.)

c. In some cases, *light* has the same effect as
chlorine, under the influence of light, unites direc

d. Electricity likewise favours the combinatio
gases, acting chiefly, perhaps, by elevation of tem
bination of oxygen with hydrogen, carbonic oxi
chlorine with hydrogen, is easily brought about.

e. In some instances, the *expansion of gaseous*
others. Phosphorus undergoes slow combustion i
perature may be, the action going on more quickly
of oxygen and non-inflammable phosphoretted hy

f. The presence of a *solid body*, particularly
surface, likewise causes, sometimes at ordinary,
peratures, the combination of oxygen with infl
would otherwise take place only at a red heat. T
hibited by platinum; the more finely divided the
When the combination of oxygen with inflammab
heat developed raises its temperature and thereby
the metal becomes red-hot and then sudden comb
condense gases, particularly oxygen, on its surface,
made to approach one another and combine. A s
and other porous bodies (p. 761).

A body in the act of chemical combination ofte
same kind of activity in another body and causin
thereby forming a compound which, under the ex
been formed without the presence of the first b
262). Nitrogen gas does not by itself combine w
if a mixture of nitrogen and hydrogen be set on
water, and a portion of the nitrogen combines at t
nitric acid. Pure copper does not dissolve in
bined with zinc and nickel (in German silver),
water, or when combined with three times its w
pletely together with the other metals. Platinu
nitric acid, but when alloyed with silver it becom

Chemical compounds may be formed, either by
substitution of one element for another in a comp

Oxygen unites directly with most other elemen
temperatures; so likewise do *sulphur*, *chlorine*, *io*
directly with oxygen and chlorine at elevated t
ordinary temperatures, under the influence of ligh
to unite directly with any other element; *phos*
chlorine, iodine, and bromine at ordinary tempe
with aid of a moderate heat. *Carbon*, at high
oxygen, sulphur, and many metals, not with any
combine directly with oxygen at ordinary tem
minute division, more easily when heated; with
no power of direct combination. *Metals* unite dir
chlorine, bromine, and iodine, sometimes at ordi
tures; in some instances also with phosphorus a
constitution are also frequently produced by melti
the greater number of such products are merely m

It has been already mentioned that compound
directly, forming new bodies of more complex co
sometimes very energetic, as that of anhydrous
phuric anhydride, which is a true case of combust

her, however, the cases in which compounds are formed by direct union of s small compared with that in which new compounds result from the trans- of others previously existing. Such transformations may be effected in ays.

eat, which may either expel one or more of the elements of the original com- he free state, leaving the rest in a new form of combination, or may cause of the elements to arrange themselves in the form of new compounds.— e of potassium, $KClO^3$, exposed to a full red heat, gives off the whole of its nd is converted into chloride of potassium, KCl. Similarly with other chlo- with bromates and iodates. Many metallic oxides and sulphides, when redness, give off part of their oxygen or sulphur, and are reduced to lower sulphides.—2. Chlorate of potassium exposed to a degree of heat less than to expel the whole of the oxygen, is resolved into perchlorate and chloride um: $3KClO^3 = KCl + 2KClO^4 + O$. Nitrate of ammonium, $NH^4.NO^3$, is y heat into water, $2H^2O$, and nitrous oxide, N^2O. To this head likewise e numerous transformations of organic compounds, resulting from dry or e distillation.

lectricity.—The action of the electric current on chemical compounds, either d state or in solution, gives rise to an endless variety of new products. In ances, the elements of a compound are eliminated by electrolysis in the free when water, hydrochloric acid, or certain metallic oxides, chlorides, or iodides ted to the action of the current; frequently, however, the elements arrange s in new combinations. We shall consider this subject more fully under ITY; at present we will merely mention the formation of peroxide of lead at e pole, when a solution of nitrate or acetate of lead is electrolysed; the evo- arsenetted hydrogen in the electrolysis of aqueous arsenious acid; and the tions of acetic acid and other fatty acids, into alcohol-radicles, hydrocarbons rsh gas series, carbonic anhydride, and hydrogen.

the action of another substance, simple or compound.

decomposing substance is an element (or a compound acting as such), and place of one element of the compound, which is thereby eliminated. This is UBSTITUTION.

ecomposes hydrochloric acid, HCl, forming $Zn''Cl^2$, and expelling hydrogen. decomposes water, HHO, expelling half the hydrogen, and forming hydrate um, KHO. Chlorine decomposes bromide of silver, forming chloride of eliminating bromine. Metals in numerous instances displace other metals ions of their salts, *e.g.* iron decomposes nitrate of copper, forming nitrate of deposit of copper. Silicic anhydride, SiO^2, decomposes carbonate of soda, expelling carbonic anhydride, and forming silicate of soda, $Na^2O.SiO^2$, t exactly in the proportion here indicated. Boric anhydride, B^2O^3, heated ate of barium expels 3 atoms of water, and forms borate of barium: $B^2O^3 +$ 'O) $= 3Ba''O.B^2O^3 + 3H^2O$.

acting body sometimes enters into combination with both elements of the , or with the compound as a whole.

e of carbon burnt in oxygen produces sulphurous and carbonic anhydrides. ons and organic compounds in general yield, by combustion, carbonic anhy- water. Chlorine converts metallic sulphides into chloride of sulphur and hlorides. Chlorine passed into water forms hydrochloric and hypochlorous decomposes metallic oxides in like manner, forming with mercuric oxide, example, chloride of mercury, $Hg''Cl^2$, and hypochlorous anhydride, Cl^2O. s only one compound is formed: as when a metallic sulphide is heated in the nverted into a sulphate: *e.g.* $Cu''S + O^4 = Cu''SO^4$; or again, when phos- hydrogen, PH^3, is converted by combustion into phosphoric acid, PH^3O^4.

substance by which the compound AB is decomposed, is itself a compound he transformation consists in an interchange of elements, whereby the two ounds AD and BC, are produced. This is DOUBLE DECOMPOSITION. It is the ent of all kinds of chemical action, and, as we shall presently explain, may d as typical of the rest. Instances of it may be adduced without number e mutual decomposition of neutral salts, *e.g.* chloride of barium and sulphate ; nitrate of silver and chloride of sodium, &c. Also the decomposition of xides by acids, resulting in the formation of chlorides, iodides, sulphides, &c. n-salts: thus, with hydrochloric acid and oxide of copper:

$$Cu''O + H^2Cl^2 = Cu''Cl^2 + H^2O;$$

ric acid and hydrate of potassium:

$$KHO + HCl = KCl + HHO;$$

sulphydric acid and oxide of lead:

$$H^2S + Pb''O = H^2O + Pb''S.$$

Sulphuric acid and protoxide of iron:

$$H^2SO^4 + Fe''O = Fe''SO^4 + H^2O;$$

sulphuric acid and sesquioxide of iron:

$$3H^2SO^4 + Fe^2O^3 = Fe^2(SO^4)^3 + 3H^2O.$$

Similarly when compound radicles are concerned, as in organic comp formation of water and chloride of ethyl by the mutual action of alc chloric acid:

$$\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O + HCl = C^2H^5Cl + H^2O;$$

of ethylsulphuric acid and water, from alcohol and sulphuric acid:

$$\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O + \left.\begin{matrix}H\\H\end{matrix}\right\}SO^4 = \left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}SO^4 + \left.\begin{matrix}H\\H\end{matrix}\right\}O;$$

of thiacetic acid and phosphoric anhydride, from acetic acid and p phosphorus:

$$5\left(\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O\right) + P^2S^5 = 5\left(\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}S\right) + P^2O^5,$$

of ethylamine by the action of hydrate of potassium on cyanate of eth

$$\underset{\text{Cyanate of ethyl.}}{N\left\{\begin{matrix}(CO)''\\C^2H^5\end{matrix}\right.} + \underset{\text{Hydrate of potassium.}}{\left.\begin{matrix}K^2\\H^2\end{matrix}\right\}O^2} = \underset{\text{Carbonate of potassium.}}{\left.\begin{matrix}(CO)''\\K^2\end{matrix}\right\}O^2} + \underset{\text{Ethylamine.}}{N\left\{\begin{matrix}H^2\\C^2H^5\end{matrix}\right.}$$

In some cases, the decomposition of a compound, AB, is effected by of two substances C, D, not previously combined; as when an oxide, ample, is decomposed by the joint action of chlorine and carbon at a re a chloride and carbonic oxide:

$$Al^2O^3 + Cl^6 + C^3 = Al^2Cl^6 + 3CO.$$

Sometimes, instead of the two new compounds AD, BC, being pro such compound, AD, is formed, the elements B C being either set free other combinations. Thus when chloride of ammonium is decomposed the products should be chloride of calcium and oxide of ammonium; is immediately resolved into ammonia and water:

$$2NH^4Cl + Ca''O = Ca''Cl^2 + (NH^4)^2O\ [= 2NH^3 + H^2$$

Aluminium and other triatomic metals do not form carbonates: salt of aluminium is precipitated by an alkaline carbonate, the precipit of carbonate of aluminium, but of alumina (hydrated), while carbonic free:

$$Al^2Cl^6 + 3Na^2CO^3 = 6NaCl + Al^2O^3 + 3CO^2.$$

Many peroxides heated with hydrochloric acid yield water, a proto metal, and free chlorine, the metal not forming a chloride analogous in the peroxide:

$$MnO^2 + 4HCl = 2H^2O + Mn''Cl^2 + Cl^2.$$

In many cases, one or both of the new products, AD, BC, enters in with an undecomposed portion of one or both of the original compound products formed depending upon the proportion in which the original present, and on the circumstances of the experiment. Thus, when sul is decomposed by potash, the immediate products are sulphide of carbonic anhydride; but these unite with portions of the original sub carbonate and sulphocarbonate of potassium:

$$3CS^2 + 3K^2O = K^2O.CO^2 + 2(K^2S.CS^2).$$

Sulphide of antimony fused with potash, yields at first sulphide of pota of antimony; but the final products are oxysulphide of antimony and of potassium:

$$3Sb^2S^3 + 3K^2O = Sb^2O^3.Sb^2S^3 + 3K^2S.Sb^2S^3;$$

but when 4 at. trisulphide of antimony are fused with 7 at. potash, t 2 at. sulphantimonite and 1 at. acid antimonite of potassium:

$$4Sb^2S^3 + 7K^2O = 2(3K^2S.Sb^2S^3) + K^2O.2Sb^2O^3.$$

already been stated that double decomposition may be viewed as a type of action in general; in fact, all cases of simple substitution, and even of the on of two elements, or the separation of the elements of a binary compound, ewed as double decompositions, provided we make certain suppositions re- he constitution of elements in the free state.

re many considerations which tend to show that the atoms of an elementary f a compound radicle in the free state, are associated by pairs in a similar the heterogenous atoms of a binary compound; that is to say, a molecule drogen consists of HH, and a molecule of free ethyl of $C^2H^5.C^2H^5$, just as a f hydrochloric acid consists of HCl, and a molecule of chloride of ethyl of In the voltaic circuit, the metallic conductor exhibits in many respects the omena as the electrolyte, both parts of the circuit becoming heated, and ucing the same deflection of a magnetic needle placed near them: hence inferred, that the metallic conductor consists of a series of similar particles n pairs, just as the electrolyte consists of a series of heterogeneous particles ised. In a circuit composed of zinc, platinum, and hydrochloric acid, lyte may be regarded as consisting of $\overset{-}{\text{Cl}}\overset{+}{\text{H}}$ $\overset{-}{\text{Cl}}\overset{+}{\text{H}}$ $\overset{-}{\text{Cl}}\overset{+}{\text{H}}$ . . . and the rt of the circuit of $\overset{-}{\text{Zn}}\overset{+}{\text{Zn}}$ $\overset{-}{\text{Zn}}\overset{+}{\text{Zn}}$ $\overset{-}{\text{Zn}}\overset{+}{\text{Zn}}$ . . . $\overset{-}{\text{Pt}}\overset{+}{\text{Pt}}$ $\overset{-}{\text{Pt}}\overset{+}{\text{Pt}}$ . . . the entire ng thus made up of atoms in opposite polar states. This, as will be more fully in the article ELECTRICITY, is the most satisfactory idea that can be given nomena of electro-chemical action.

re are also considerations purely chemical which tend to the same conclusion. ances of chemical action are known, in which two atoms of an elementary mpound radicle unite together at the moment of chemical change, just like ous atoms.

hen hydride of copper, Cu^2H^2, is decomposed by hydrochloric acid, cuprous formed, and a quantity of hydrogen evolved, equal to twice that which is in the hydride itself:

$$Cu^2H^2 + 2HCl = Cu^2Cl^2 + H^2H^2.$$

n is precisely analogous to that of hydrochloric acid on cuprous oxide:

$$Cu^2O + 2HCl = Cu^2Cl^2 + H^2O.$$

er case, the hydrogen separated from the hydrochloric acid unites with oxy- he former, with hydrogen. When solutions of sulphurous and sulphydric nixed, the whole of the sulphur is precipitated:

$$SO^2 + 2H^2S = 2H^2O + S.S^2,$$

being similar to that of sulphurous acid on selenhydric acid:

$$SO^2 + 2H^2Se = 2H^2O + S.Se^2.$$

case, a sulphide of selenium is formed; in the other, a sulphide of sulphur. itation of iodine, which takes place on mixing hydriodic with iodic acid, imilar instance of the combination of homogenous atoms. The reduction of tallic oxides by peroxide of hydrogen, is another striking example of this ion. When oxide of silver is thrown into this liquid, water is formed; the educed to the metallic state; and a quantity of oxygen is evolved, equal to which is contained in the oxide of silver. It appears, indeed, as if atoms exist in a state of isolation. An atom of an elementary body must unite, an atom of another element, or with one of its own kind.

phenomena are exhibited by the alcohol-radicles: thus, when zinc-ethyl and nethyl are heated together, double decomposition takes place, the products le of zinc and methyl-ethyl:

$$Zn''(C^2H^5)^2 + 2(CH^3.I) = ZnI^2 + 2(CH^3.C^2H^5);$$

zinc-ethyl is heated with iodide of ethyl, a precisely similar action takes attended with formation of free ethyl:

$$Zn''(C^4H^5)^2 + 2(C^2H^5.I) = ZnI^2 + 2(C^2H^5.C^2H^5).$$

case, the ethyl separated from the iodine unites with methyl separated from n the second, it unites with another atom of ethyl. The idea of the duality ecules of alcohol-radicles in the free state, is likewise in accordance with ved boiling-points and vapour-densities. (See ALCOHOL-RADICLES, p. 96.)

elementary bodies frequently act upon others as if their atoms were asso- binary groups. Thus chlorine acting upon potash forms two compounds, d hypochlorite of potassium:

$$KKO + ClCl = ClK + ClKO;$$

just as chloride of cyanogen would form chloride and cyanate of pot quantity of chlorine which acts upon an atom of potash, is not 1 at 2 at. = 70. Similarly, when metallic sulphides oxidise in the air, both t the sulphur enter into combination with oxygen. Sulphur acting upon p sulphide and a hyposulphite. Lastly, when zinc-ethyl is exposed to chlorine, iodine, &c., these elements unite separately with the zinc and w thus:

$$Zn''(C^2H^5)^2 + 2ClCl = 2C^2H^5Cl + Zn''Cl^2$$

From these considerations it appears that double decomposition, whic understood as an action between four elements or groups of elements, ma supposed to take place in cases where only three elements or groups co In like manner we may regard as double decompositions even those re are commonly viewed as the simple combination or separation of two el the substitution of one element for another. Thus when potassium bur gas, the reaction may be supposed to take place between two atoms of two atoms of potassium:

$$KK + ClCl = KCl + KCl.$$

Again, the decomposition of cyanide of mercury by heat may be represe

$$Hg''Cy^2.Hg''Cy^2 = 2CyCy + HgHg.$$

The simple replacement of one element by another may also be regarde decomposition, by supposing the formation of an intermediate compour action of zinc upon hydrochloric acid may be supposed to consist of two

$$ZnZn + 2HCl = Zn''H^2 + Zn''Cl^2,$$

and

$$Zn''H^2 + 2HCl = Zn''Cl^2 + 2HH.$$

It is true that the formation of the intermediate compound, the hydride not be actually demonstrated in this case, because it is decomposed as fast a but in other cases, the two stages of the action can be distinctly traced well known that hydrochloric acid does not dissolve copper; but an allo copper, Cu^2Zn, dissolves in it readily, with evolution of hydrogen. H supposed that the first products are chloride of zinc and hydride of cop compound:

$$Cu^2Zn + 2HCl = Cu^2H^2 + Zn''Cl^2;$$

and that the hydride is afterwards acted upon by the acid in the mann plained. Again, when zinc and iodide of ethyl are heated together in iodide of zinc and zinc-ethyl are obtained, thus:

$$ZnZn + 2(C^2H^5).I = ZnI^2 + Zn''(C^2H^5)^2;$$

and the zinc-ethyl, when heated with excess of iodide of ethyl, yields and free ethyl (p. 857).

It thus appears that all well understood cases of chemical action may one type, namely, that of an interchange of elements between two previ compounds.

d. The transformation of a compound is brought about by a substanc remains unaltered, or at all events does not enter into combination with elements of the compound. This obscure mode of action, usually calle *Contact-action*, is chiefly observed in the transformations of organic comp the conversion of sugar into alcohol and carbonic acid, and of alcohol i under the influence of yeast; of starch into dextrin and sugar by the actio the conversion of urea into carbonate of ammonium, by contact with anin The terms Catalysis and Contact-action explain nothing, but as mer are sometimes convenient. Many decompositions formerly spoken of as now regarded as double decompositions, dependent on the polarity of atoms (p. 857).

Magnitude or Strength of Chemical Affinity.

That the power which causes bodies to unite is exerted with vari intensity, is evident from the whole range of chemical phenomena. Chl unites with hydrogen more readily than with nitrogen, and the eleme chloric acid are held together with far greater force than those of chlori If zinc displaces copper from its solution in hydrochloric acid, and copp place zinc from such a solution, we cannot resist the conclusion that zinc for chlorine in solution is greater than that of copper. But does the former of these affinities is intrinsically and under all circumstance

er? or may not the relative solubilities of chloride of zinc and chloride of
or the cohesion of the metals themselves, have something to do with the result?
ate the question generally, does each element possess for every other a dis-
d specific affinity or combining power, which is always the same, and liable
be modified in its results by the circumstances under which the bodies are
—or is the affinity between each pair of elements itself a variable quantity
nt on pressure, temperature, solubility, volatility, the presence of other
&c. &c.? The older chemists answered the first part of this question in the
ive. When they found a body A expelling another B from its union with C,
ncluded that C had for A a greater affinity than for B.

his principle they formed what were called *Tables* or *Columns of Affinity*, of
he following may be taken as specimens, the several substances in each being
l in the order of their supposed affinity for the body at the head of the
:

ur: O; K and the other alkali-metals; Zn; Fe; Sn; Cu; Cl; H; C; Pb;
Hg; Ag; Pt; Cu^2S; MoS; Au.

uric acid: BaO; SrO; K^2O; Na^2O; Li^2O (?); CaO; MgO; PbO; NH^3;
nO; NiO; CoO; CuO; Al^2O^3; Fe^2O^3.

s: O; F; Cl; Br; I; Se; P; H.

y slight acquaintance with chemical phenomena is, however, sufficient to show
se so-called Tables of Affinity are merely tables of the order of decomposition
rticular circumstances, and that the relative affinity of one body for two others
to change from a great variety of circumstances, sometimes even to be re-
Thus, iron at a red heat decomposes vapour of water, abstracting the oxygen
ing the hydrogen free, whence it might be inferred that the affinity of oxygen
is greater than for hydrogen; but if hydrogen gas be passed over red-hot
iron, water is formed and iron set free, indicating an exactly opposite order
ties. In like manner, potassium heated in an atmosphere of carbonic anhydride,
oxidised and sets carbon free; and on the other hand, charcoal strongly
with potash, abstracts the oxygen and sets potassium free. Carbonic anhy-
recipitates silica from a solution of silicate of sodium, and on the other hand
ated with carbonate of sodium, forms silicate of sodium, and liberates carbonic
de; and similarly in numerous other cases.

ust then look to other circumstances besides intrinsic force of affinity to de-
whether a particular reaction will take place or not. The most important
circumstances are:

e *elasticity* or the *cohesion* of one of the resulting compounds, and its con-
tendency to assume the gaseous or solid state, and thus to remove itself from
re of action.

xamples just mentioned afford striking illustrations of the influence of vola-
determining chemical decomposition. The tendency of the resulting gas or
to diffuse itself through the surrounding atmosphere, doubtless contributes
to the result; thus, when aqueous vapour is passed over red-hot iron, the hy-
set free by the decomposition of the water is carried forward by the current
ous vapour, and the iron is left free to act upon a fresh portion. The influence
sion is clearly seen in precipitations. It is, indeed, a general law that if the
s of two salts are mixed, and an insoluble compound can be formed from any of
ements, that compound is sure to be produced and to separate from the liquid.

he order of decomposition is frequently reversed by the nature of the solvent.
acetic acid decomposes carbonate of potassium, eliminating carbonic acid;
he resulting acetate of potassium be dissolved in alcohol, and carbonic acid
sed through the solution, carbonate of potassium is precipitated and acetic acid
nto solution as acetic ether. A strong solution of caustic potash decomposes
te of calcium, forming carbonate of potassium, and leaving lime undissolved;
lution of 1 pt. carbonate of potassium in 10 pts. of water, is decomposed by
n with lime, yielding caustic potash and carbonate of calcium. A weak
of sulphurous acid dissolves iodine, forming hydriodic and sulphuric acids,
$+ I^2 + H^2O = 2HI + H^2SO^4$; but if the quantity of water in the solution be
ned by evaporation, sulphurous anhydride is evolved and hydriodic acid con-
iodine remains behind, $H^2SO^4 + 2HI = I^2 + SO^2 + 2H^2O$.

e relative quantities of the acting substances.—That the relative degrees
ity of a body for a number of others to which it is simultaneously presented
atly modified by their relative masses, was first pointed out by Berthollet.
laid down by that philosopher respecting the action of masses, is this: —*A
which two different substances capable of acting on it chemically, are presented
ent proportions, divides itself between them in the ratio of the products of their*

respective masses, and the absolute strengths of their affinities for the first if we denote by A and B the masses of the two bodies which are present α and β the coefficients of their absolute affinities for the body C; and the quantities of A and B which actually combine with C, the law just s expressed by the proportion:

$$a : b = \alpha A : \beta B.$$

If this view be correct, any alteration, however small, in the relative q and B, must produce a corresponding alteration in the relative quantiti which unite with C. That this is not the case under all circumstances, the following experiments of Bunsen and of Debus.

Bunsen's experiments (Ann. Ch. Pharm. lxxxv. 137), which were m manner that all the phenomena of combination concerned in them took neously, lead to the following remarkable laws:

1. When two or more bodies, BB' . . . are presented in excess to under circumstances favourable to their combination with it, the body A of the bodies BB' . . . quantities which stand to one another in a s relation, so that for 1, 2, 3 . . . atoms of the one compound, there are 1, 2, 3 . . . atoms of the other; and if in this manner there is formed a compound $A B'$, in conjunction with an atom of AB, the mass of the bo increased relatively to that of B', up to a certain limit, without produci tion in the atomic proportion.

When carbonic oxide and hydrogen are exploded with a quantity o sufficient to burn them completely, the oxygen divides itself between th such a manner that the quantities of carbonic anhydride and water prod one another in a simple atomic proportion. The results of Bunsen's ex given in the following table, the numbers in which denote volumes:

Composition of Gaseous Mixture.			Quantities of CO and H consumed by Detonation.	
72·57 CO	. 18·29 H	. 9·14 O	12·18 CO	. 6·10 H
59·93 „	. 26·71 „	. 13·36 „	13·06 „	. 13·66 „
36·70 „	. 42·17 „	. 21·13 „	10·79 „	. 31·47 „
40·12 „	. 47·15 „	. 12·73 „	4·97 „	. 20·49 „

The results were the same whether the explosion took place in the da daylight, or in sunshine; and were not affected by the pressure to whi mixture was subjected.

The proportions of hydrogen and carbonic oxide consumed in these s ments, correspond with the composition of five hydrates of carbonic anhy ing, respectively:

$$H^2O.2CO^2;\ H^2O.CO^2;\ 2H^2O.CO^2;\ 3H^2O.CO^2;\ 4H^2O.CO^2$$

but the results cannot be attributed to the actual formation of these h much as hydrates of acids containing several atoms of water are incapab at high temperatures.

2. *When a body, A, exerts a reducing action on a compound, BC, pre so that A and B combine together and C is set free; then, if C can, in a reducing action on the newly-formed compound, AB, the final result is, that the reduced portion of BC is to the unreduced portion in a proportion.*

In this case, also, the mass of the one constituent may, without alteri atomic relation, be increased to a certain limit, above which, that rela changes by definite steps, but always in the proportion of simple ration

When vapour of water is passed over red-hot charcoal, the carbon i hydrogen is separated; but the process does not go on so far as the com of carbonic anhydride, but stops at the point at which 1 vol. carbonic 2 vol. carbonic oxide are formed to every 4 vol. of hydrogen.

In the imperfect combustion of cyanogen—the gaseous mixture being that it will but just explode, in order that the temperature may not ris the result be consequently vitiated by the partial oxidation of the nitro anhydride and carbonic oxide are formed, and nitrogen set free, like atomic proportion. A mixture of 18·05 vol. cyanogen, 28·87 oxyg nitrogen, gave, by detonation, 2 vol. carbonic oxide, and 4 vol. carboni 3 vol. nitrogen.

combustion of a mixture of carbonic anhydride, hydrogen, and oxygen, in
carbonic anhydride is exposed at the same time to the reducing action of the
and the oxidising action of the oxygen, the reduced portion of the carbonic
is likewise found to bear to the unreduced portion a simple atomic relation.
nbustion of a mixture of 8·52 carbonic anhydride, 70·33 hydrogen, and 21·15
e resulting carbonic oxide was to the reduced carbonic anhydride in the
: 2. After the combustion of a mixture of 4·41 vol. carbonic oxide, 2·96
nhydride, 68·37 hydrogen, and 24·26 oxygen, the volume of the carbonic
verted into carbonic anhydride by oxidation, was to that of the residual
xide as 1 : 3.

ese remarkable laws had not been previously observed, is attributed by
the fact that they hold good only when the phenomena of combination,
regulated by them, take place simultaneously: for, even if a body *A* were
to select for combination from the bodies *B* and *C*, quantities bearing to
er a simple atomic relation, but the combination of *A* and *B* were to take place
er time than that of *A* and *C*, it would follow of necessity, that during the
the process, the ratio of *B* to *C*, and therefore, also the atomic relations of
ated compounds, would change, so that the observed proportion would be no
inite. The same result must follow if the bodies which are combining side
e not homogeneously mixed in the beginning.

gard to the bearing of these results on Berthollet's law, it might be objected
me of the experiments, as in the combustion of a mixture of carbonic oxide,
and oxygen, one of the products, viz. the water, is removed from the sphere
by condensation, and that the circumstances are therefore similar to the
f an insoluble product by precipitation. It is scarcely conceivable, however,
verse action would take place, even if the gaseous mixture were to remain
perature which exists during the combustion. Moreover, in the decompo-
vapour of water by red-hot charcoal, the whole of the products remain in the
tate.

(Ann. Ch. Pharm. lxxvx. 103; lxxxvi. 156; lxxxvii. 238), has obtained
nilar to those of Bunsen, by precipitating mixtures of lime and baryta-water
ous carbonic acid, or mixtures of chloride of barium and chloride of cal-
carbonate of sodium. A small quantity of a very dilute solution of car-
sodium added to a liquid containing 5 pts. of chloride of barium to 1 pt. of
f calcium, threw down nearly pure carbonate of calcium; but when the pro-
the chloride of barium in the mixture was 5·7 times as great as that of the
of calcium, 2·3 pts. of the former were decomposed to 1 pt. of the latter.
appears that, in this reaction also, limits exist at which the ratio of the
undergoes a sudden change. In these experiments, however, the products
diately removed from the sphere of action, and the results are therefore not
le with those which are obtained when all the substances present remain
l free to act upon each other.

tter condition is most completely fulfilled in the mutual actions of liquid
s, such as solutions of salts, when all the possible products of their mutual
s likewise soluble; as, for example, when nitrate of sodium in solution is mixed
hate of copper. The question to be solved in such cases is this. Suppose two
CD, the elements of which can form only soluble products by their mutual
ge, to be mixed together in solution. Will these elements, according to their
ffinities, either remain in their original state of combination, as AB and CD,
mpletely into the new arrangement AD and CB ? — or will each of the two
de itself between each of the two bases, producing the four compounds AB,
BD ? and, if so, in what manner will the relative quantities of these four
s be affected by the original quantities of the two salts ? Do the amounts of
CB, produced by the reaction, increase progressively with the regular increase
required by Berthollet's theory ? or do sudden transitions occur, like those
in the experiments of Bunsen and Debus ?

ution of this question is attended with considerable difficulty. For when two
olution are mixed, and nothing separates out, it is by no means easy to as-
hat changes may have taken place in the liquid. The ordinary methods of
ng the composition of the mixture, such as concentration, or precipitation by
are inadmissible, because any such treatment immediately alters the mutual
f the substances present. In some cases, however, the mixture of two salts
d with a decided change of colour, without any separation of either of the
ts, and such alterations of colour may afford indications of the changes which
e in the arrangement of the molecules. This method has been employed by
lstone (Phil. Trans. 1855, 179; Chem. Soc. Qu. J. ix. 54), who has carefully
the changes of colour attending the mixture of a great variety of salts, and

applied the results to the determination of the effect
action.

Dr. Gladstone's principal experiments were made w
of iron, which is formed on adding sulphocyanic aci
to a solution of a ferric salt. On mixing known quant
known quantities of different sulphocyanates, it was
completely converted into the red salt; that the am
on the nature both of the acid combined with the fe
bined with the sulphocyanogen; and that it mattered
been combined previous to their mixture, so long as t
together in solution. The effect of mass was tried b
of ferric salts and sulphocyanates, and then adding kn
compound. It was found that, in either case, the amo
and in a regular progression according to the quanti
of potassium was mixed in various proportions with fe
the rate of variation appeared to be the same, but wi
different. The deepest colour was produced when ferr
cyanate of potassium; but even on mixing 1 at. of th
only 0·194 at. of the red sulphocyanate of iron was
of sulphocyanate of potassium had been added, ther
of ferric nitrate undecomposed. The results of a s
nitrate and sulphocyanate of potassium are given in t

Ferric Nitrate.	Sulphocyanate of Potassium.	Red Salt produced.	Ferric Nitrate.
1 equiv.	3 atoms.	88	1 atom.
1 "	6 "	127	1 "
1 "	9·6 "	156	1 "
1 "	12·6 "	176	1 "
1 "	16·2 "	195	1 "
1 "	19·2 "	213	1 "
1 "	28·2 "	266	1 "
1 "	46·2 "	318	

The addition of a colourless salt reduced the colo
cyanate, the reduction increasing in a regularly pr
mass of the colourless salt.

Similar results were obtained with other ferric salt
red meconate and pyromeconate, the blue solution of
and likewise with the coloured salts of other metals
the red iodide of platinum, the blue sulphate of cop
chlorides, &c.

The amount of fluorescence exhibited by a solutio
found to be affected by the mixture of a chloride, br
nature and mass of the salt added; and the additio
and other acids was found to produce a fluorescenc
quinine, or of sulphate which had been rendered non-fl
chloric acid. Solutions of horse-chestnut bark, and
similar results.

The conclusions to be drawn from Gladstone's exp

When two or more binary compounds are mixed u
the resulting compounds are free to act and react, e
bination with each basylous element in certain con
pendent of the manner in which the different elemen
not merely the resultant of the various strengths of
for each other, but are dependent also on the mass o
the mixture. All deductions respecting the arran
drawn from such empirical rules as that the stronges
base, must therefore be looked upon as doubtful. A
the binary compounds present, alters the amount
compounds, and that in a regularly progressive ratio
where a substance is present, which is capable of
than one proportion. This equilibrium of affinities
inappreciably short time; but, in certain instances,
final state of combination for hours.

Totally different phenomena present themselves
crystallisation, and perhaps other actions occur, sim

noved from the field of action, and the equilibrium, which was at first is thus destroyed.

procal action of salts in solution has also been examined by **Malaguti** Phys. [3] xxxvii. 198; and by **Margueritte** (Compt. rend. xxxviii. 305), om conclude that each base divides itself between the several acids. Maladles from his experiments that, in the mutual action of two salts, if nothing om the liquid, the decomposition is most complete when the strongest acid ongest base are not originally united in the same salt, and that two experiis kind, made in opposite ways, must lead to the same final result; that, e, when 1 at. of acetate of barium is added to 1 at. of nitrate of lead, the of nitrate of barium and nitrate of lead ultimately present in the liquid are s when 1 at. nitrate of barium is mixed with 1 at. acetate of lead.

itte finds that two salts in solution decompose each other, even when one of eady the least soluble of the four salts that may be produced from the acids present. Thus, a saturated solution of chlorate of potassium to which sodium is added, becomes capable of dissolving an additional quantity of potassium, showing that a portion of the chlorate has been decomposed soluble salt formed.

re, however, certain well known phenomena, which show that this districids and bases in solution does not always take place. Boric acid colours e-red; sulphuric acid turns it bright red. Now if sulphuric acid be graed to a warm solution of borate of sodium in water which has been coloured itmus, the liquid at first remains blue, because a combination of soda with oric acid is produced; on the addition of more sulphuric acid, boric acid is nd colours the liquid wine-red; and not till all the soda has entered into n with the sulphuric acid does a further addition of that acid give the liquid d colour; but if sulphuric acid were present at the commencement of the ner in the free state or combined with sulphate of sodium in the form of an he bright red colour would appear at once. From the same cause, a solution e of potassium or sodium to which boric acid has been added, colours litmus red; but the addition of $\frac{1}{5000}$ of sulphuric acid immediately produces the tint. Hence boric acid does not take soda from sulphuric acid or set that —Sulphydric acid and carbonic acid exhibit similar relations towards sull.—Tincture of litmus is instantly bleached by chlorine-water, but not till al days by aqueous solution of iodine: now, a solution of chloride of sodium h iodine should, according to Berthollet, produce a mixture containing f sodium with excess of chlorine, and iodide of sodium with excess of ut the orange-yellow mixture colours litmus green (from the yellow of the d the blue of the tincture): and a very small quantity of chlorine-water y changes this green colour into the orange-yellow of the solution of iodine: that no chlorine had been set free by the iodine.—Ferric phosphate is hydrochloric acid, but not in acetic acid. From its solution in hydrochloric completely precipitated by acetate of potassium. Now if the potash had ed between the hydrochloric and acetic acids, part of the hydrochloric acid e remained free, and would have held some of the phosphate of iron in (Gm. i. 153.)

omposition of soluble by insoluble salts, affords a striking instance of the f atoms to interchange, and of the influence of mass on chemical action. to H. **Rose** (Pogg. Ann. xciv. 481; xcv. 96, 284), sulphate of barium is decomposed by boiling with solutions of alkaline carbonates, provided that of sulphate of barium is acted upon by at least 15 at. of the alkaline When 1 at. of sulphate of barium is boiled with only 1 at. of carbonate of only $\frac{1}{5}$ of it is decomposed, and only $\frac{1}{11}$ by boiling with 1 at. of carbonate further decomposition being prevented by the presence of the alkaline sulady formed. If, however, the liquid be decanted after a while, the residue h a fresh portion of the alkaline carbonate, and these operations repeated nes, complete decomposition is effected. Carbonate of barium is converted ate by the action of an aqueous solution of sulphate of potassium or sodium, dinary temperatures. Solution of carbonate of ammonium does not decomate of barium either at ordinary or at higher temperatures; carbonate of not decomposed by sulphate of ammonium at ordinary temperatures, but boiling. Sulphate of barium is not decomposed by boiling with caustic ation, provided the carbonic acid of the air be excluded; but by fusion with potassium it is decomposed, with formation of carbonate of barium, because ic acid of the air cannot then be completely excluded. Hydrochloric and , left in contact at ordinary temperatures with sulphate of barium, either crys- precipitated, dissolve only traces of it: at the boiling heat, a somewhat

larger quantity is dissolved, and the solution forms a
of chloride of barium and with dilute sulphuric acid.
by hydrochloric acid at ordinary temperatures, suffici
with dilute sulphuric acid, and with chloride of
treated with hydrochloric acid, either cold or boiling,
pitate is formed, after a while, by dilute sulphuric aci

Sulphate of strontium and sulphate of calcium are co
of the neutral and acid carbonates of the alkali-meta
more quickly on boiling, even if considerable quantitie
to the solution: the decomposition is also effected by
ordinary temperatures. The carbonates of strontium
by solutions of the sulphates of potassium or sodiu
of ammonium does not decompose them at ordinary te
aid of heat.

Sulphate of lead is completely converted into carb
and acid carbonates of the alkali-metals, even at or
carbonates, but not the acid carbonates, then dissol
lead. Carbonate of lead is not decomposed by sol
either at ordinary temperatures or on boiling.

Chromate of barium is decomposed at ordinary t
neutral carbonates of the alkali-metals, and much
cess of an acid carbonate of alkali-metal. When equi
of barium and carbonate of sodium are boiled with
posed; when the same quantities of the salts are fuse
with water, only $\frac{1}{21}$ of the barium-salt is decomposed
pletely converted into chromate by digestion with t
chromate; and the decomposition of chromate of bariu
even at the boiling heat, is completely prevented by t
of an alkaline monochromate.

Selenate of barium is easily and completely deco
carbonates, even at ordinary temperatures: this salt i
more readily in dilute acids.

Oxalate of calcium is decomposed by alkaline car
ratures; but to effect complete decomposition, the li
and renewed. The decomposition takes place rapidl
cases it is completely prevented by the presence of
alkaline oxalate. When the salts are mixed in equiva
of calcium are decomposed at ordinary temperatures, a
cium is partially converted into oxalate by the actio
of potassium at ordinary temperatures, and more qu
position is never complete, even when the liquid is f
—Oxalate of lead is completely converted into carbo
the solution of an alkaline carbonate, a small portion o
in the liquid. (Rose.)

The preceding experiments exhibit in a remarkable
of solubility in determining the order of decomposit
soluble than the carbonate, and, accordingly, carbona
composed by alkaline sulphates than the sulphate by al
contrary relations are exhibited by the sulphates an
calcium, both as regards solubility and order of dec
oxalate of calcium is less soluble than the carbonat
alkaline carbonates takes place more easily than th
the order of decomposition appears rather to be det
ments (p. 862), by the tendency of the strongest acid

The effect of a soluble sulphate, &c. in arresting the
ing insoluble salts by alkaline carbonates, is evident
the reverse action: hence the acceleration produced
liquid. Some insoluble salts, however, phosphate of ca
pletely decomposed, even by this treatment. (See als
li. 328.)

Theories of Chemical Act

Chemical combination was in early times attribu
Hippocrates that "like assorts with like:" hence th
have been first employed by Barchhusen. Becher a
dogma, that when two bodies are capable of combin

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* According to Fresenius, carbonate of strontium dissolves in
in 6895 parts of water.

Others, among whom was Lemery, supposed that solvents are furnished
nber of sharp points, by means of which they are more or less adapted to
hemselves into the pores of solid bodies and combine with them.
ng these crude notions, we have to consider four distinct hypotheses which
proposed to account for the phenomena of chemical action.

ical combinations are produced by universal attraction.
was the first who referred chemical combination to universal attraction,
did not regard the attraction between ultimate particles as exactly the
that which acts between the great bodies of the universe.
llet also regarded chemical combination as a manifestation of the force of
ttraction, exhibiting peculiar characteristics, because it is exerted, not on
t on molecules placed at extremely small distances from each other. Being
ed with the laws of combination in definite proportions, he supposed that
virtue of their affinity, are essentially capable of uniting in all proportions,
ited what he considered the apparent exceptions to the law, entirely to the
f cohesion and elasticity. That these causes exert considerable influence on
ombination, is sufficiently evident from the phenomena already discussed;
pose that combination in definite proportion is absolutely dependent upon
d be inconsistent with our present knowledge of the constitution of chemical
; indeed, the single fact that chlorine and hydrogen unite in one proportion
form hydrochloric acid gas, without any condensation or expansion, is quite
o show the untenability of such a supposition.

*ical combinations are produced by a peculiar power called Affinity, distinct
rsal attraction.* Universal attraction, as manifested in gravitation, acts
all substances in proportion to the mass, whereas in chemical phenomena
h of the attraction is determined especially by the peculiar nature of the
concerned.

nion of heterogeneous atoms is the result of Electrical attraction.
s theories of this kind have been proposed, among others by Davy, Dumas,
Ampère, Grotthuss, Schweigger, Fechner, Berzelius and L. Gmelin.
us supposed that "The atom of every substance has two poles, on which the
ctricities are accumulated in different proportions, according to the nature
es. The atom of many bodies, oxygen for instance, has a large quantity of
lectricity attached to one of its poles, and but a very small quantity of
ctricity at the other; that of other bodies, potassium for example, has a
ity of positive electricity at one pole, and a very little negative electricity
r. Thus the elementary substances are divided into *electro-negative* and
tive. To each element, however, there belongs a particular proportion be-
quantities of the two electricities. Oxygen has, of all the electro-negative
he greatest quantity of negative electricity at one of its poles, and the smallest
positive electricity at the other,—then follows sulphur, then nitrogen, &c.,
ydrogen, in which the quantities of the two electricities are nearly equal.
tro-positive substances, potassium has the largest quantity of positive and
st of negative electricity; and this inequality continually diminishes in
es, till we come to gold, in which the positive electricity predominates but
the negative—so that this element occupies the next place to hydrogen.
to this, the elements succeed one another in the electro-chemical series
s as follows, beginning with the electro-negative.
-negative, O, S, N, F, Cl, Br, I, Se, P, As, Cr, V, Mo, W, B, C, Sb, Te, Ta,

-positive, Au, Os, Ir, Pt, Rh, Pd, Hg, Ag, Cu, U, Bi, Sn, Pb, Cd, Co, Ni, Fe,
, Th, Zr, Al, Y, G, Mg, Ca, Sr, Ba, L, Na, K.
combination of an electro-negative with an electro-positive body, the predo-
gative electricity of the former unites with the predominant positive elec-
he latter. Before, however, combination takes place, the former substance
gative, and the latter positive electricity in the free state; and the tension
electricities continually increases as the bodies approach the temperature
ombination takes place. Hence we have an explanation of *electricity by con-*
he instant of combination, the negative poles of the atoms of the first body
elves towards the positive poles of those of the second; and since it is only
state that the atoms possess the mobility necessary for this arrangement, it
t solid bodies have, generally speaking, no chemical action on one another.
ectricities of these poles now combine and produce heat or fire, whereupon
pear. In every chemical combination, therefore, a neutralisation of the opposite
takes place, by which heat or fire is produced in the same manner as in the
of the electrical pile or of lightning, excepting that these last-mentioned
are not accompanied by any chemical combination, at least of ponderable

bodies. Every chemical combination is therefore a
ing on the electrical polarity of the atoms."

The main difficulty of this theory is to account
atoms are held together. The heterogeneous ator
adhesion to the opposite electricities; but when the
bination, it might be expected that the atoms would
to be easily separated by friction and other mechan
This objection to the theory of Berzelius has never

Gmelin's theory is as follows:—"Ponderable bo
The two electricities are substances which likewise
by whose combination in the proportions in which
(fire) is produced. The individual electricities, anc
affinity for ponderable substances, and are united t
greater quantity, the more simple these pondera
bodies, according to their nature, have a greater or
electricity united with them, in addition to a definite
probably contains the greatest quantity of *positive*,
city. Bodies lying between these two extremes, con
a smaller excess of one or the other kind of electricit
greatly according to their nature.

"The combination of two ponderable bodies is t
affinity of the ponderable bodies for each other,
which is in excess in the one body for the opposite
the other. By these two forces, the affinity of
positive electricity united with it, and that of the ele
electricity combined with it, are overcome. The
compound. The latter retains the excess of positive
it requires either an electro-negative or electro-posit
the heat—while another portion is set free, and giv
or fire, by which most chemical combinations are a
takes place between two bodies, both of which con
of electricity, *e.g.* oxygen and sulphur, which co
different quantities,—it is simplest to suppose tha
merely of the affinity between the two ponderabl
contains the sum of the excesses of positive electric
heat is a consequence of the inability of the new
united with it as was before combined with its const

4. *Chemical action results from a constant motion*
bodies, this same movement likewise giving rise
and electricity. This is the theory suggested by
vi. 110). The atoms of all compounds, whether sim
be continually changing places, the interchange t
atoms resemble each other more closely. Thus, in
atom of hydrogen is supposed, not to remain quietly
chlorine with which it happens to be first united, but
with other atoms of hydrogen, or, what comes to the
associated with other atoms of chlorine. This inte
eye, because one molecule of hydrochloric acid is ex
the hydrochloric acid to be mixed with a solution
ponent atoms of which are likewise undergoing
elements, hydrogen and copper, then no longer limit
of atoms with which they were at first combined, but
change places with each other, forming chloride of
it is that, when two salts are mixed in solution, anc
quence of their mutual action, the bases are divided
are produced. If, however, the analogous elements
dissimilar, and, consequently, interchange but slowly,
acid and the stronger base remain almost entirely t
combined with each other. This is strikingly seen
(sulphate of hydrogen) and borate of sodium, which
verted into sulphate of sodium and free boracic acid

Now, suppose that, instead of sulphate of copper,
hydrochloric acid. At the first moment, the intercha
to take place as above, and the four compounds, H
be formed; but the last being insoluble, is immed
the remaining elements then act upon each other
goes on till all the chlorine or all the silver is r

if the original compounds are mixed in exactly equivalent proportions, esult is the formation of only two salts, viz. in this case, H^2SO^4 and AgCl. esult is produced when one of the products of the decomposition is volatile sting temperature, as when hydrate or carbonate of sodium is boiled with ammonium.

cipitation or volatilisation takes place, and one of the compounds (hydrod) is in excess of the other (sulphate of copper), then, as the atoms of their several interchanges must come in contact with chlorine-atoms more than with SO^4-atoms, the final result must be the formation of a larger chloride of copper and of sulphate of hydrogen than if the bodies had been quivalent proportions, this effect of course increasing as the relative quantity loric acid is greater in the original mixture; and thus we have an explanaeffect of mass in chemical reaction.

e theory affords an easy explanation of certain chemical changes otherwise obscure. Consider, for example, the formation of ether by the action of acid upon alcohol, whereby ethyl-sulphuric acid (sulphate of ethyl and is first formed, and afterwards, at a certain temperature, ether and water ated (p. 76). When alcohol, $\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O$, and sulphuric acid, $\left.\begin{matrix}H\\H\end{matrix}\right\}SO^4$, are ther, the interchange between the atoms of ethyl in the former and of n the latter gives rise to the formation of ethyl-sulphuric acid and water:

$$\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O \;+\; \left.\begin{matrix}H\\H\end{matrix}\right\}SO^4 \;-\; \left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}SO^4 \;-\; \left.\begin{matrix}H\\H\end{matrix}\right\}O.$$

nge does not stop here: for the ethyl-sulphuric acid thus produced, meeting molecules of alcohol, exchanges its ethyl for the hydrogen of the alcohol, ther and sulphuric acid:

$$\left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}SO^4 \;+\; \left.\begin{matrix}C^2H^5\\H\end{matrix}\right\}O \;=\; \left.\begin{matrix}C^2H^5\\C^2H^5\end{matrix}\right\}O \;+\; \left.\begin{matrix}H\\H\end{matrix}\right\}SO^4.$$

ric acid is thus restored to its original state, and is ready to act upon fresh f alcohol; so that if alcohol be allowed to run into the mixture in a conm, the temperature being kept within certain limits (between 130° and e process goes on without interruption, ether and water continually distil he same quantity of sulphuric acid suffices for the etherification of an untity of alcohol. This is the peculiarity of the process; it has given rise of explanations, all more or less unsatisfactory, the discussion of which reign to the present purpose; it is sufficient to remark that the hypothesis interchange affords a ready explanation of the chief peculiarity of the rethe formation and decomposition of ethyl-sulphuric acid following each nuously, without any change of temperature or other determining cause. nitted that the atoms of ethyl and hydrogen in the mixture are continually ng in all possible ways, this series of alternate actions follows as a necesuence.

of atomic motion is in accordance with physical as well as chemical pheTo suppose that rest, rather than motion, is the normal state of the particles s at variance with all that we know of the effects of light, heat, and electhe theory of heat, the particles of bodies are supposed to be affected with as well as with rotatory and vibratory movements; and this same hypoogressive movement, which of course implies change of relative position particles, affords, as already stated, an easy explanation of certain chemical herwise difficult to understand.

CHOLIC ACID. $C^{27}H^{44}O^4$.—An acid obtained by boiling tauroacid, the sulphuretted acid of goose-bile, with baryta-water, and decomresulting barium-salt with hydrochloric acid. It is insoluble in water, but lcohol and ether, whence it separates as an amorphous mass. The solutions id reaction, and give the characteristic blood-red colour with sugar and cid. It is insoluble in cold potash, but when heated with it, forms a salt n freed from excess of potash, dissolves readily in water and in alcohol. -salt consists of $C^{27}H^{43}BaO^4$. (Heintz and Wislicenus, Pogg. Ann.

COPROLITE. An impure iron sinter, containing a little silver and cobalt. It is a product of decomposition, not a distinct mineral.

PODIUM. The herb of *Chenopodium ambrosioïdes* yields by distillation, enish-yellow volatile oil (about 1½ oz. from 10 lb.) having an aromatic and

cooling taste (H. Becker, Zeitschr. Pharm. 1854,
this oil, dehydrated by chloride of calcium and r
boiling at 179° to 181° C.

Chenopodium maritimum.—The ash of this p
claimed from the sea, has been analysed by Har
the following results: *a.* Flowers and young shoo

	K^2O	Na^2O	CaO	MgO	Fe^2O^3	CO
a.	4·4	2·3	4·2	6·6	4·3	0·
b.	3·1	5·0	4·4	2·0	2·5	0·

Traces of manganese were also found. The flow
31·9 per cent. ash, and the stems 24·3 per cent.
proportion of chloride of sodium in the ash, seem
were saturated with salt water. *Aster tripoliu*
yielded a very large amount of ash, containing ab
and leaves, and 30 per cent. in the flowers.

Chenopodium olidum.—This plant contains
C^3H^9N, either trimethylamine or propylamine, to
due. (Dessaignes, Compt. rend. xxxiii. 358.)

Chenopodium Quinoa.—According to Völcker
seeds dried at 100° C. contain 46·10 per cent. sta
4·60 gum, 5·74 oil, 8·91 casein with a little solub
and other albuminoïdal compounds, 9·53 veget
deduction of sand and charcoal) contained 36·
sodium, 2·45 lime, 13·61 magnesia, 1·78 ferric ox
sulphuric anhydride, and 2·19 silica.

CHERT. A term often applied to hornston
cluding the jaspers. (See *Ure's Dictionary of A*

CHESSYLITE or **CHESSY COPPER.** S
OF COPPER, p. 784.)

CHESTERLITE. See FELSPAR.

CHESTNUT. *Castanea vesca.*—The fruit
Payen (J. Pharm. [3] xvi. 279) and by Albini
found in 100 pts.:

	Water.	Ash in d Substa
Of the cultivated chestnut . .	54·21	4·0
Of the wild chestnut . . .	48·06	3·2

Albini found in the shelled kernels of dried ch
3·0—3·3 per cent. ash, 1·2—2·1 fat, 23·2—38·0 st
sugar, 6·5—8·4 cellulose, 0·9—2·1 vegetable albu
compounds.

According to Dessaignes (J. Pharm. [3] xxv
agine, but no quercite.

The entire fruit of the tree (undried) yields 0·9
36·33 K^2O, 19·18 Na^2O, 7·84 CaO, 7·84 MgO, 5
7·33 P^2O^5, 1·9 phosphates of calcium, magnesia, a
son, Jahresber. f. Chem. i. 1074.)

CHIASTOLITE. *Hollow Spar. Macle.*
crystallised in right rhombic prisms with angles
into the end of the prism, we perceive in the axis
by the other, which is of a greyish, yellowish, or re
of the interior prism, a blackish line extends to th
In each of these outer angles there is usually a sm
same dark substance which composes the central
clay-slate with the rock in which the chiastolite i
double cleavage. Translucent. Scratches glass.
negative electricity. Specific gravity 2·94. Har
it is convertible into a whitish enamel. It has bee

of Barège, and in Galicia in Spain, near St. Iago de Compostella. The
crystal is properly an elongated four-sided pyramid. U.

A red dye, obtained from the leaves of *Bignonia Chica*. (See CARAJURU,

ENITE. A phosphate of aluminium and iron (ferrosum) found with
vistock in Devonshire, and at Crinnis in Cornwall. Rammelsberg found
nens:

P^2O^5	Al^2O^3	$Fe''O$	$Mn''O$	$Ca''O$	$Mg''O$	H^2O	Total.
29·36	18·77	30·75	6·12	0·66	—	17·00	102·66
28·92	14·44	30·68	9·07	—	0·14	16·98	100·23

ting 3·82 per cent. of insoluble residue in I. and 4·03 in II.).
analysis II., which was made with purer material than I., Rammelsberg
formula: $2(4M''O.P^2O^5) + 2Al^2O^3.P^2O^5 + 15H^2O$, which may be reduced to
rthophosphate with hydrate of aluminium and water, viz.: $(M'')^8al'''(PO^4)^6$.
10aq. The crystals belong to the trimetric system: $P . \frac{4}{3}P . 3P\infty . P\infty . \infty P$
eavage parallel to P and $\infty\breve{P}\infty$ (Brooke, Rammelsberg). Specific gravity
Hardness = 5 (Rammelsberg). The crystals, which are transparent,
sy lustre, and vary in colour from yellowish-brown to blackish, are found
ace of spathic iron ore intergrown with quartz, iron pyrites, and copper
rooke, Ann. Phil. vii. 316.—Rammelsberg, Pogg. lxxxv. 435; Phil. Mag.
)

ITE. Syn. with GÖTHITE.

ONITE. Syn. with PREHNITE.

LINE. C^9H^7N. *Quinoleine*, *Leucol* (Runge, Pogg. Ann. xxxi. 68.—
, Ann. Ch. Pharm. xlii. 310; xliv. 279.—Hofmann, *ibid.* xlvi. 31; liii.
15.—Bromeis, *ibid.* lii. 130.—Laurent, Ann. Ch. Phys. [3] xix. 367.
ille Williams, Ed. Phil. Trans. xxi. [2]; [3] 377; Jahresber. f. Chem.
8; 1856, p. 532.—v. Babo, J. pr. Chem. lxxii. 73.—Gm. xiii. 243).—
839, obtained from coal-tar an organic base to which he gave the name of
rhardt, in 1842, obtained a similar product, *quinoleine*, by distilling quinine
organic bases with potash. Hofmann showed that Gerhardt's quinoleine
s leucol were identical. Laurent first pointed out that Gerhardt's quino-
mixture, a fact afterwards established by Gr. Williams, who separated
ine from it, as well as from the mixture of bases obtained from coal-tar.
to later experiments by Williams, however, the chinoline from coal-tar
differ in some respects from that which is obtained from cinchonine, &c.
as also succeeded in preparing from chinoline (obtained from cinchonine),
colouring matter likely to be useful in dyeing.

n.—Chinoline is produced in numerous reactions:—1. In the dry distilla-
, passing over with the tar (Runge).—2. By distilling cinchonine, quinine,
ne with hydrate of potassium (Gerhardt).—3. By the electrolysis of
cinchonine (v. Babo).—4. By distilling thialdine with milk of lime
and Liebig, Ann. Ch. Pharm. lxi. v.)—5. By the dry distillation of tri-
r trigenate of silver (Liebig and Wöhler, *ibid.* lix. 289).—6. By dis-
erine with milk of lime, or hydrate of lead (Bödeker, Ann. Ch. Pharm.
Bödeker also states that chromate of pelosine heated to 100° C. gives off a
chinoline and phenic acid; but according to Williams (Jahresber. d.
p. 375), the only volatile products of this decomposition are methylamine.
ine, and a pyrrol-base. Williams is of opinion that the production of
some of the above reactions has been inferred merely from its odour,
ality, not a trace of it has been present.

ion.—1. From *Cinchonine*. Pulverised cinchonine is gradually added to
potassium, which is heated in a retort till it melts; the mixture is then raised
temperature till it becomes brown and emits stifling vapours (Gerhardt);
tillate, which is a mixture of several bases, is boiled with an acid for
s, whereby pyrrhol is driven off. The dry chinoline which afterwards
, beginning to boil at 149° C., but not passing over in large quantities till
point rises to 183°, is separated by repeated fractional distillation (about
into several portions, the lowest of which boils between 154° and 160°,
hest, which is the largest in quantity, at 271°. Of these fractions, that
ls below 165° contains lutidine, with a little pyridine and picoline; that
7° and 182° contains collidine, which is also found in the products up to
the portion which distils above 199°, especially that between 216° and
ts of chinoline and lepidine, the latter being found chiefly in the portion

boiling above 270°. To obtain chinoline (and t
individual fractions are converted into platinum
crystallisation. (Williams.)

2. *From Coal-tar Oil.*—*a.* The mixture of p
obtained from heavy coal-tar oil (see PHENYLAMIN
and neutralised with oxalic acid; and the mothe
of phenylamine which has crystallised out, is disti
changed as soon as the distillate no longer produc
of calcium, and the chinoline which afterwards pa
mann). Chinoline thus obtained, contains lepidi
b. Fifty gallons of the oil of very high boiling point
with sulphuric acid, and the acid liquid is distilled
tillate which sinks in water, contains chinoline, le
of bases of the phenylamine series. The latter ar
sium and hydrochloric acid (see PHENYLAMINE);
heavy oil containing phenic acid; the admixed no
steam through the liquid; the residue is filtered t
separated from the aqueous solution by potash, an
The mixture thus obtained yields, after more tha
portions boiling between 177° and 274°, and from
fractional crystallisation of the platinum-salts, as a

Properties.—Chinoline is a transparent, colou
which neither thickens or freezes at −20° C. (Ho
1·081 at 10° (Hofmann). It conducts electri
(Hofmann), boils steadily at 238° C. and distils
evaporates even at ordinary temperatures, so tha
paper soon disappears. The vapour-density of c
243° C. is 4·519 (Williams). Chinoline has a p
phorus and of hydrocyanic acid (Runge), of S
bitter-almond oil (Hofmann). It does not ap
The aqueous solution kills leeches, but when intro
produces only transient convulsive symptoms a
alkaline to litmus and turmeric (Gerhardt,
(Hofmann).

Several formulæ have been proposed for chino
Hofmann and Bromeis (made on chinoline contain
it is C^9H^8N; Gerhardt at first regarded it as C^9H^1
$C^{10}H^9N$. The formula C^9H^7N, first suggested by
analyses of several of the salts; the pure base doe
The formula C^9H^7N gives for the vapour-density, c
4·47 which agrees very nearly with Williams's det

Chinoline is very sparingly soluble in cold wate
extracted from the solution by ether (Hofmann)
0° C. it forms a clear oil containing $2C^9H^7N.3H^2O$,
becomes turbid. When chinoline saturated with wa
and a little chinoline escape, and a clear hydrate
which remains limpid and mobile at −20°, but is re
anhydrous chinoline. (Bromeis.)

Chinoline mixes in all proportions with *sulph*
spirit, *aldehyde*, and *acetone;* it also mixes with
dissolves *phosphorus*, *sulphur*, and *arsenic*, also c
not copal or caoutchouc. It does not coagulate alb

Decompositions.—1. Chinoline when set on fire,
flame.—2. It becomes resinised by exposure to the a
into a black resin, with great rise of temperature
(Hofmann), into a yellow oil, which is decom
insoluble substance (Williams).—4. With *brom*
mann).—5. Aqueous chinoline treated with a
chlorate of potassium rapidly becomes covered wi
solidifies to a tough mass on cooling (Hofman
violently on chinoline, and converts it into a sple
form any products of decomposition (Gr. Willi
takes fire in contact with dry *chromic acid*, and is
(Hofmann).—8. *Permanganate of potassium* dec
and ammonia Hofmann).—*Potassium* dissolves
drogen, but without colouring. On melting potas
potassium is formed. Chinoline vapour passed ove

part unchanged, but forms a small quantity of cyanide of potassium (Hofmann).—10. Chinoline passed over *red-hot quick lime* (Hofmann), or *soda-lime* (Bromeis), suffers little or no decomposition.—11. Enclosed in a sealed tube with *iodide of methyl*, and heated for ten minutes to 100° C., it is changed into crystals of hydriodate of methyl-chinoline. In like manner, it is converted by *iodide of ethyl* into hydriodate of ethyl-chinoline, and by *iodide of amyl* into hydriodate of amyl-chinoline (Williams).—12. Chinoline becomes warm when mixed with *sulphate of methyl* (sometimes disengaging vapour of methylic ether and methylic alcohol), and forms, if complete combination has been promoted by heat, a liquid soluble in water, which, when excess of sulphate of methyl is present, deposits separate crystals. The liquid is rendered turbid by potash or baryta, and separates oil-drops, which at first become red, then green, finally violet, and when heated pass into a beautiful violet resin, *methylirisine*, with formation of sharp, strongly smelling, condensable vapours. At the same time a brown resin and a sulphomethylate are formed. Chinoline, heated to boiling with *sulphate of ethyl*, forms a colourless liquid, which, when boiled with strong caustic potash, deposits a violet resin, *ethylirisine*, insoluble in ether, and a brown resin soluble in ether, while an ethylsulphate remains dissolved, and a sharp neutral oil, sinking in water, passes over, which, if immediately mixed with dichloride of platinum, yields beautiful needles, but soon decomposes (v. Babo).—13. *Chloride of acetyl* acts violently on chinoline, forming a crystalline very deliquescent mass (Williams).—14. With *cyanate of ethyl*, it solidifies into a crystalline mass consisting of phenyl-chinyl-carbamide, $N^2(CO)''.C^6H^5.C^9H^5.H^2$.

CHINOLINE SALTS.—Chinoline unites with acids, forming salts which crystallise easily (Williams). It precipitates salts of aluminium and ferricum, and renders lead-salts and ferrous salts slightly turbid (Hofmann). According to Gerhardt, it precipitates nitrate of silver, but not ferric nitrate.

Chinoline salts are decomposed by fixed alkalis; also by ammonia at a moderate heat; but at high temperatures, chinoline expels ammonia. Dry chinoline-salts treated with phenylamine, emit the odour of chinoline. (Hofmann.)

Chlorhydrate or *Hydrochlorate of Chinoline.*—Chinoline absorbs hydrochloric acid gas violently, and with evolution of heat, and solidifies on cooling to white crystals, which take up more hydrochloric acid, becoming red and liquid, and on again cooling, solidify to a deliquescent, slightly crystalline mass. Hence chinoline appears to form both a neutral and an acid hydrochlorate (Bromeis). When hydrochloric acid gas is passed over chinoline dissolved in ether, the hydrochlorate separates in heavy viscous drops, which after a while become slightly crystalline (Hofmann). Mixed with solutions of metallic chlorides, it forms double salts, which for the most part crystallise readily.

Chlorantimonite.—Chinoline forms with trichloride of antimony a white precipitate, which dissolves in boiling hydrochloric acid, and crystallises on cooling (Hofmann).

Chloro-aurate. $C^9H^7N.HCl.AuCl^3$.—Delicate canary-yellow needles, permanent in the air, sparingly soluble in water, and containing, when dried at 100° C. 41·85 per cent. of gold; the formula requires 42·0 per cent. (Williams.)

Chlorocadmate. $C^9H^7N.HCl.CdCl^2$.—The concentrated solutions of hydrochlorate of chinoline and chloride of cadmium solidify to a pulp when mixed: the dilute solutions yield white permanent needles, which give off 2 at. water at 100° C., volatilise completely at a higher temperature, and are sparingly soluble in alcohol. (Williams.)

Chloromercurate. $C^9H^7N.Hg''Cl^2$.—White precipitate, which is not decomposed by boiling water (Hofmann), and separates on cooling in beautiful pearly plates (Bromeis). It smells of chinoline, and has a very bitter, disagreeably metallic taste. According to Hofmann's analysis, it contains 26·5 per cent. C, 17·6 Cl, and 49·9 Hg, the formula requiring 27·0 C, 17·75 Cl, and 50·0 Hg.

Chloropalladite. $2(C^9H^7N.HCl).PdCl^2$.—Chestnut-brown crystals, containing 20·96 per cent. Pd; by calculation 21·18 per cent. (Williams.)

Chloroplatinate. $2(C^9H^7N.HCl).PtCl^4$.—Yellow crystalline precipitate, which dissolves in 393 pts. of water at 15° C. (Williams). The salt obtained by fractional crystallisation, fourteen times repeated, from a portion of the bases (prepared from cinchonine, p. 869), boiling between 238° and 243°, yielded 32·36 per cent. C, 2·74 H, and 29·29 Pt, the formula requiring 32·06 C, 2·58 H, and 29·19 Cl. (Williams.)

Chlorostannite. Hydrochlorate of chinoline forms with protochloride of tin a yellow, heavy oil, which afterwards becomes crystalline, and dissolves with difficulty in alcohol. (Hofmann.)

Chloro-uranate. $2(C^9H^7N.HCl).(U^2O^2)''Cl^2$.—Concentrated solutions of ammonio-chloride of uranyl and hydrochlorate of chinoline solidify when mixed: dilute solutions yield beautiful yellow prisms, containing (at 100° C.) 31·87 per cent. C, 2·77 H, and 20·97 Cl, the formula requiring 32·05 C, 2·37 H, and 21·07 Cl. (Williams.)

Chromate of Chinoline.—Chromic acid form
with chinoline (**Gerhardt**, **Hofmann**). Dilute c
aqueous chinoline (obtained from cinchonine), throws
matter, which becomes crystalline when rubbed wit
water after filtering and washing, and is deposited in
detonates when heated, but not after addition of hyd
by analysis, 45·08 per cent. C, 3·49 H, and 22·34 Cr
formula $2C^9H^7N.H^2O.2CrO^3$ (**Williams**). Chinoli
crystallised compound with chromic acid, but only oil
which could be destroyed by chromic acid had been r

Nitrate of Chinoline.—Solution of chinoline in
evaporated over the water-bath, a pasty mass, whic
crystallised from hot alcohol, forms white needles,
100° C., and consisting of $C^9H^7N.HNO^3$ (**William**
alcohol, insoluble in ether. (**Hofmann.**)

Oxalate of Chinoline, is a confused, radiating
water, alcohol, and ether (**Hofmann**). An *acid oxal*
mixing a solution of 16·5 pts. oxalic acid in a small
of chinoline, as a soft, white, crystalline mass, which
forms slender needles having a silky lustre. It deco
of chinoline. (**Williams.**)

When chinoline containing phenylamine is dissolv
with alcoholic oxalic acid, almost all the oxalate of
few hours, while oxalate of chinoline remains in solu

Picrate of Chinoline resembles picrate of phe

Sulphate of Chinoline.—Crystallisable and
Hofmann.)

Tannate of Chinoline.—Chinoline forms with i
precipitate (**Hofmann**); a white flocculent precipi
in alcohol. (**Gerhardt.**)

Substitution-Derivatives of

METHYL-CHINOLINE, $C^{10}H^9N = N.H.CH^3.C^9H^6$.
xxi. [3] 577.)—Not known in the free state, at least in
obtained in fine crystals, by heating chinoline and io
in a sealed tube for ten minutes. It is decomposed
of silver, and an unstable, strongly alkaline solution
emits a suffocating odour, probably arising from m
$2(C^{10}H^9N.HCl).PtCl^4$, is obtained as a sparingly s
solution of the hydriodate with nitrate of silver, p
with hydrochloric acid, and adding tetrachloride of p

ETHYL-CHINOLINE, $C^{11}H^{11}N = N.H.C^2H^5.C^9H^6$.

Chinoline treated with iodide of ethyl, as in th
methylchinoline, yields, after distilling off the exce
hydriodate of ethylchinoline. On treating these cryst
(if this is done in the water-bath, a volatile product
and filtering off the iodide of silver, a colourless, st
chinoline is obtained, which decomposes on evaporati
carmine colour, and on the edges emerald-green, af
blue. It expels ammonia from sal-ammoniac. It pr
the salts of lead, iron, and copper.

Hydriodate of Ethylchinoline, $C^{11}H^{11}N.HI$, forms c
cohol. It is more soluble in water than in alcohol. It
4·4 H, and 44·1 I, the formula requiring 46·3 C, 4·9

At 100° C., it becomes transiently blood-red. It is
forming iodide of silver, and a liquid which is colou
over the water-bath, assumes a carmine colour, dark
leaves a blackish-red mass having a coppery lustre
dark carmine solution, which is coloured scarlet by h
rose-red by ammonia: with potash, it forms a violet p
soluble in water, but dissolves in alcohol, forming a c
of platinum produces in the hydrochloric acid solu
insoluble double salt, of a higher atomic weight than t
of ethylchinoline.

Platinum-salt of Ethylchinoline. $2(C^{11}H^{11}N.HCl)$.
soluble precipitate.

g v. Babo's compounds, *methyl-* and *ethyl-irisine*, which appear to be iso-
methyl- and ethyl-chinoline, see p. 870; also the names of the substances

INOLINE, $C^{14}H^{17}N = N.H.C^5H^{11}.C^9H^6$ (Gr. Williams, *loc. cit.*)—A
chinoline and iodide of amyl heated in a sealed tube for several hours to
posits beautiful crystals of the hydriodate, $C^{14}H^{17}N.HI$. The *platinum-*
$^{17}N.HCl).PtCl^4$, is sparingly soluble in water, insoluble in ether-alcohol.

ate of amyl-chinoline heated with alkalis, yields a fine blue colour, which
d as a dye. To prepare it, 1 pt. by weight of crude chinoline is to be boiled
ntes with 1½ pts. of iodide of amyl. The mixture, from being straw-coloured
eep reddish-brown, and solidifies on cooling to a mass of crystals. This
the reaction is to be boiled for about ten minutes with 6 pts. of water, and,
lved, filtered through paper. The filtered liquid is to be gently boiled in
ed iron pan over a small fire, and excess of ammonia gradually added.
ion may be prolonged with advantage for one hour, the evaporation of the
g compensated for by the gradual addition of weak solution of ammonia,
y the admixture of equal volumes of ammonia of the density of 0·880 and
ater. The hour having elapsed, the whole is allowed to cool, when the
almost entirely have precipitated, leaving the supernatant liquid nearly
On pouring the fluid away (preferably through a filter, in order to retain
rticles of colour) the dish will be found to contain resinous looking masses
olve readily in alcohol, yielding a rich purplish-blue solution, which may be
kept for use.

ur prepared as above is of a purplish tint, but if a purer blue be required
ng modification is to be resorted to. The filtered aqueous solution of hy-
amyl-chinoline, is, as before, to be brought to the boiling temperature; but
adding ammonia, a solution of caustic potash containing about one-fifth of
of solid potash is to be substituted. The addition is to be continued at
ntil three-fourths as much potash has been added as is equivalent to the
he iodide of amyl used. The fluid may, after a quarter of an hour's ebul-
ltered to separate the resinous colour. The product is a gorgeous blue with
y shade of red. On adding the other fourth of potash to the filtrate while
ing, a black mass will be precipitated containing all the red, which other-
l have been mixed with the blue. This mass dissolves readily in alcohol,
rich purple solution containing, however, an excess of red. The alcoholic
filtration, leaves on the filter a dark mass soluble in benzene, and as some-
ared, affording a brilliant emerald-green solution of great beauty. It is not
y to obtain this green colour.

y the chinoline prepared from cinchonine that yields these colouring matters:
ch points to an essential difference between this product and the isomeric
among the products of the distillation of coal. Cinchonine distilled with
otash, yields about 65 per cent. of crude chinoline; and all the distillate
rectification (p. 869), distils above 199° or 209° C. (390° or 408° F.), up
hest range of the mercurial thermometer, is suitable for the preparation
ur. One pt. of this distillate and 1½ pts. iodide of amyl, yield 23 pts. of
ontaining 4 per cent. of solid colouring matter. (Gr. Williams, *Chemical*
, p. 219.)

e-violet and chinoline-blue are resinous substances, which present a coppery
by reflected light, but when in very thin layers, appear of a violet or blue
transmitted light. They are bases and dissolve in acids, forming pale red
which ammonia restores to their original colours. They are slightly soluble
er. Tannin precipitates them from their aqueous solutions, apparently
insoluble compound. Reducing agents do not affect their shade of colour.
rkin, Chem. Soc. Qu. J. xiv. 246.)

mes of chinoline-blue mixed with 1 vol. of Magenta pink (fuschine), of the
rength found in commerce, form a fine purple inclining to blue (Williams).
rine is passed through an alcoholic solution of chinoline-blue, a green
roduced, which is perhaps the green spoken of by Williams. (Perkin.)

ONE. Syn. with QUINONE.

ITE. A fluoride of aluminium and sodium, $Na^3Al^2F^9$, occurring at Miask
l, in snow-white, translucent, octahedral crystals, of the dimetric system,
he principal is to the secondary axes as 1·077 : 1; also massive, granular
cryolite, with crystalline structure. Specific gravity 2·72 (Hermann);
98 (Rammelsberg). Hardness = 4. Analysis by Hermann (J. pr.
vii. 188), gave 23·78 per cent. Na, 18·69 Al, the formula requiring 23·4 and
s easily before the blowpipe, and gives the reaction of fluorine. (Dana, ii. 98.)

CHITIN (from χιτών, a tunic). (Odier, Mém
—Lassaigne, J. Chim. méd. ix. 379; Compt. ren
xvii. 227.—C. Schmidt, *Zur vergleichenden*
1845, p. 32; and Ann. Ch. Pharm. liv. 298.—
1844, p. 7.—Frémy, Ann. Ch. Phys. [3] xliii. 94
xcviii. 99.—Städeler, *ibid.* cxi. 21.—Gerh. *Tra*
Traité, vi. 93.)—The name given by Odier to the
elytræ and integuments of insects and the carapac
by exhausting the wing-cases of cockchafers suc
acetic acid, and boiling alkalis. The final residu
wing-cases. Frémy prepares chitin by treating t
taceous animal with cold dilute hydrochloric acid,
with distilled water; boiling for several hours wit
adhering albuminous substances, and has no acti
distilled water; and purifying the residue with alc

Chitin thus prepared is solid, transparent, of h
hol, and ether. It is coloured brown by solutio
upon it. By boiling with dilute acids, it is res
compound. (Städeler.)

When chitin (from the carapace of the crab) is
sulphuric acid, only the softer membranes are at
ments become loose and soft, and form, after pres
having almost the consistence of starch. The a
and then neutralised with sulphuric acid, yields
tains ammonia, together with amorphous sugar,
oxide abundantly from an alkaline solution of cup
(Ann. Ch. Phys. [3] lvi. 149) likewise obtained su
integuments of lobsters, crabs, and cantharides,)
acid till it was dissolved, dropping the solution i
boiling water, boiling for an hour, saturating with

The above-mentioned pasty residue is coloured
chitin, and by prolonged boiling with sulphuric ac
sugar, while the undissolved portion always conta
after removal of the acid, forms with water a turb
to clarify, and dries up by spontaneous evaporatio
exhibits, with iodine-water, the same reactions as

The composition of chitin is determined by the

	Schmidt. Mean of 11 analyses.	Lehmann.	Sc
Carbon . . .	46·64	46·73	
Hydrogen . .	6·60	6·59	
Nitrogen . .	6·56	6·49	
Oxygen . .	40·20	40·19	
	100·00	100·00	

Frémy found in chitin 43·35 carbon, 6·65 hydr
gards chitin as isomeric with cellulose (44·4 C, 6·2
Frémy's results as more correct than those of t
yields by dry distillation only acetic acid and emp
and the products of its putrefaction under water a
genous substances. But the analyses above give
which could scarcely be expected if the substanc
(See Cellulose, p. 818.)

Städeler regards chitin as a glucoside, $C^9H^{15}N$
acids into glucose and lactamide (or alanine or sa

$$C^9H^{15}NO^6 + 2H^2O = C^6H^{12}$$

If this decomposition really takes place, lactic a
a product of the transformation of the lactamic
lactic acid among the products has not yet been de
that chitin (at least in crustacea) may be formed b
with gum, and elimination of water:

$$[\underset{\text{Acid lactate of ammonium}}{C^3H^4O^3.H.NH^4} + \underset{\text{Gum.}}{C^6H^{10}O^5} = C$$

inasmuch as he has found gum in the juices of cra

lactic acid in the gastric juice of the lower animals is by no means im-
.

VIATITE. A sulphide of lead and bismuth, also containing copper, from
in Peru, where it occurs, with pyrites and heavy spar, in foliated masses,
in three directions in one zone, one making an angle with the second of 153°,
the third of 133°. Specific gravity 6·920; colour lead-grey; lustre metallic.
g to Rammelsberg's analysis (Pogg. Ann. lxxxviii. 320) it contains 18·00 S,
16·73 Pb, 2·42 Co, 1·02 Fe, with trace of silver, and 0·59 insoluble matter
.), whence the formula $2(Pb^2;Cu^2)S.Bi^2S^3$. (Dana, ii. 77.)

ADNITE. See Meteorites.

DANTHITE. Native arsenide of nickel containing cobalt, also called white
(See Nickel).

OCARBETHAMIDE. Syn. with Trichloracetamide (p. 6).

ORACETAMIC ACID. Syn. with Tetrachloracetamide (p. 6).

ORACETAMIDE. See Acetamide (p. 6).

ORACETIC ACIDS. Two of these compounds are known, viz. *mono-* and
acetic acids, both being produced by the action of chlorine gas on glacial acetic
er the influence of light, the former when the acid is in excess, the latter
chlorine and the acetic acid are brought together in the exact proportions
for its formation. The trichlorinated acid is likewise produced in several
ctions. *Di*chloracetic acid has not yet been obtained, at least in definite form.

ochloracetic Acid, or simply **Chloracetic Acid.** $C^2H^3ClO = C^2H^2ClO.$
R. Hoffmann, Ann. Ch. Pharm. cii. 1.)—Dumas had observed that, in the
on of trichloracetic acid by the action of chlorine on acetic acid in sunshine
ubstitution-product is always obtained, especially if the acetic acid is in ex-
he form of an uncrystallisable acid, which however he did not succeed in pre-
the separate state. F. Leblanc afterwards obtained this acid, the monochlor-
d, in the form of a colourless liquid, by passing chlorine through glacial acetic
he shade; his product however was not quite pure. More recently Hoffmann
n that the chief product of the action of chlorine on excess of acetic acid in
, is monochloracetic acid, and that this acid, when pure, is solid and crystal-
rdinary temperatures.

ration.—1. A tubulated retort of about 1 litre capacity and containing from
und to a pound of glacial acetic acid, is placed in a bath containing a saturated
of nitrate of sodium (boiling at 120° C.), and dry chlorine gas is passed into
t by a tube inserted through the tubulure and terminating just above the
that the gas may mix immediately with the vapour of the acid. The neck
tort having a wide glass tube attached to it, is directed upwards, so that any
id which evaporates undecomposed may be condensed and flow back again,
hydrochloric acid and excess of chlorine escape. The whole apparatus is
the sunshine, and the evolution of chlorine is so regulated that the upper part
tort always appears coloured by it. The stronger the light, the more rapid is
ption of chlorine; but the action takes place, though slowly, even under a
ky. A very slow substitution of chlorine for hydrogen likewise takes place in
and at ordinary temperatures. As the formation of chloracetic acid goes on,
n slackens, so that it is best, after about fifteen hours' exposure to sunshine, or
long to diffused daylight, to expel the excess of chlorine from the apparatus by
of dry air, and rectify the product in a smaller retort. The portion which dis-
130° C. consists almost wholly of unaltered acetic acid, and may be used in
ent preparation. That which passes over between 130° and 190° is easily se-
by repeated rectification, into acetic and a thick liquid which boils between
187°, and either solidifies immediately into a mass of white needle-shaped
or yields after some time, large, isolated, transparent, colourless rhombic
hile the greater portion remains liquid, but if shaken up or stirred with a
, solidifies suddenly and with considerable rise of temperature, the crystals
y formed becoming opaque and white like porcelain. The crystalline mass,
lts between 45° and 47°, consists of nearly pure monochloracetic acid, mixed
with a certain quantity of liquid, which may be removed by decantation and
ssure, and used, together with the portion of the original liquid which distilled
0°, in a subsequent preparation. The expressed crystals are placed on bibu-
r and completely dried in vacuo over oil of vitriol and a few lumps of hydrate
ium, and then redistilled, the first and last portions of the distillate being re-
As they are very deliquescent, they should be kept as much as possible from
(Hoffmann.)

first distillation and in the subsequent rectifications, there is obtained a small
of a liquid which boils above 190°, and appears to contain an acetic acid with

more than 1 at. hydrogen replaced by chlorine. It y
from 48 to 50 per cent. of chlorine, which does not a
dichloracetic (requiring 55·04) or of trichloracetic aci
chlorine). In one experiment, this liquid, on being
besides monochloracetate of barium, a small quantity
the composition of which seemed to show that they
acid; but in no instance, even when the purest cryst
the absorption took place in the brightest sunshine,
trichloracetic obtained, the chief product being in
Neither was any oxalic acid formed, as in Dumas' pr
(p. 877). (Hoffmann.)

2. Monochloracetic acid is also obtained in a state
on monochlorinated chloride of acetyl. On distilling t
from 100° to 180°, and the liquid which passes over
a crystalline mass on cooling. (Wurtz.)

Properties.—The acid crystallises from fusion in rho
of 77° or 78°; from solution in acetic acid—*e.g.* fr
first distillation between 180° and 186°, and between
ing a prismatic character, and very much resembling th
ing point 62°. It contracts strongly in solidifying, a
air-bubbles. The specific gravity of the melted acid
water at 19°, and 1·3947 compared with water at 73
187·8°. It distils undecomposed, and when pure soli
but if mixed with acetic acid, remains liquid below its
When kept for some time at a temperature near its m
spicular crystals. It is nearly inodorous at ordinary t
a pungent suffocating odour. It has a strong acid tas
blisters if kept on it for some time. It deliquesces in
in *water*, producing considerable fall of temperature.

Decompositions.—1. The acid is decomposed by *pe*
formation of oxychloride of phosphorus and monochlor
two chlorides cannot be separated by distillation, as
When the product was repeatedly distilled with small
potassium, the residues of the last distillations yielde
proportion of chloracetic acid, the last portions of wh
had a more penetrating odour, probably arising from t
of the anhydrous acid.—2. The acid heated with *pot*
or *lime-water*, immediately yields a chloride of the
(Kekulé.)

$$C^2H^2ClMO^2 + H^2O = MCl +$$

3. Chloracetic acid is reduced by *potassium-amalga*
acid, in the same manner as trichloracetic acid; the d
plete, and is attended with evolution of hydrogen. (

The CHLORACETATES, $C^2H^2ClMO^2$, are obtained
nates in the aqueous acid: they are for the most part

Chloracetate of Ammonium decomposes by eva
It is more soluble than that salt, and solidifies only fr
the form of a crystalline cake, which deliquesces on ex

Chloracetate of Barium. $C^4H^4Cl^2Ba''O^4 + 2H^2$
very small quantities of material, in distinct prismati
to the trimetric system, and containing 39·99 per cent.
Decomposes but little during evaporation, and separate
ing from a hot saturated solution. (Hoffmann.)

Chloracetate of Potassium. *a. Neutral.* 2C
by saturating the acid with carbonate of potassium and
over oil of vitriol. It then separates in thin colourless
pure by draining on bibulous paper. It is not delique
water of crystallisation at 100° C., but is decomposed
chloride of potassium, glycollic acid, and a small
(Kekulé, Ann. Ch. Pharm. cv. 288):

$$C^2H^2ClKO^2 = KCl + C^2H$$

It is also decomposed when its solution is evaporated
luble in water. After drying in vacuo, it yielded 24·6
lution, 24·55).

b. Acid. $C^2H^2ClKO^2.C^2H^2ClO^2$.—When a solution

cid as it already contains, the whole solidifies to a thick pulp of small white
stals, which may be purified by draining on bibulous paper or by drying over
iol. Sparingly soluble in water.

cetate of Silver. $C^2H^2ClAgO^2$.—A hot solution of the acid saturated with
ilver, yields the salt on cooling in splendid rhomboïdal, iridescent laminæ
—Anhydrous. Dissolves sparingly in cold, more readily in hot water, and is
ained by cooling, in small nacreous scales, which blacken on exposure to
yield chloride of silver. Between 110° and 120° C. it decomposes with a kind
ion, emitting the same odour as the acid when it evaporates, and leaving
f silver, mixed with a very small quantity of metallic silver.

cetate of Ethyl. $C^4H^7ClO^2 = C^2H^2ClO^2.C^2H^5$. (E. Willm, Ann. Ch.
xlix. 97.)—Obtained by the action of alcohol on monochlorinated chloride of

$$C^2H^6O + C^2H^2Cl^2O = C^4H^7ClO^2 + HCl.$$

n, which is very violent, must be moderated by cooling the vessel externally,
on as it is finished, the product may be washed with water, dehydrated by
f calcium and rectified.

ess liquid, having an ethereal odour and burning taste, heavier than water
uble in that liquid. Boils at 143°·5 C. when the barometer stands at 758° mm.
ensity 4·46.

her burns with a bright flame, green at the edges. It is decomposed by
to alcohol and chloracetic acid, which then suffers further decomposition,
hloride and acetate of potassium.

loracetic Acid. $C^2HCl^3O^2 = C^2Cl^3O.H.O.$ (Dumas, J. Chim. méd. vi.
Ann. Ch. Pharm. xxxii. 101; Ann. Ch. Phys. lxxiii. 75; Melsens, Ann.
[3] x. 233; Malaguti, Ann. Ch. Phys. [3] xvi. 10; Kolbe, Ann. Ch. Pharm.
Gm. ix. 209; Gerh. i. 749.)—This acid was discovered by Dumas in 1839.
uced: 1. By the action of 6 at. dry chlorine gas on 1 at. glacial acetic acid in
(Dumas):

$$C^2H^4O^2 + 6Cl = C^2HCl^3O^2 + 3HCl.$$

oxidation of soluble chloral by a mixture of hydrochloric acid and chlorate
um, and of chloral either soluble or insoluble, by fuming nitric acid (Kolbe):

$$C^2HCl^3O + O = C^2HCl^3O^2.$$

action of chlorine gas in sunshine on dichloride of carbon covered with a
water (Kolbe):

$$C^2Cl^4 + 2H^2O + Cl^2 = C^2HCl^3O^2 + 3HCl;$$

he C^2Cl^4 is at the same time converted into C^2Cl^6.—4. In the decomposition
le of trichloracetyl (chloraldehyde) by water (Malaguti):

$$C^2Cl^4O + H^2O = C^2HCl^3O^2 + HCl.$$

decomposition of perchlorinated formic ether by water (Cloez, Ann. Ch.
xvii. 300):

$$C^3Cl^6O^2 + 2H^2O = C^2HCl^3O^2 + CO^2 + 3HCl.$$

ation.—1. When glacial acetic acid is exposed to the sun in bottles of 5 or 6
acity (in the proportion of 0·8 or 0·9 grms. of the acid to 1 litre of chlorine)
f trichloracetic acid make their appearance in about a day, together with a
ntity of oxalic acid. On opening the bottles, a mixture of hydrochloric acid
a small quantity of carbonic acid and a suffocating vapour, escapes with force.
les are then left open for some hours, till the gaseous mixture is completely ex-
nd washed out with a small quantity of water, whereby a concentrated solution
racetic acid is obtained, mixed, however, with hydrochloric acid, undecom-
tic acid, and oxalic acid. When this solution is evaporated in vacuo over oil
and hydrate of potassium, water, hydrochloric acid, and part of the acetic
pe, and the solution then yields crystals, first of oxalic, afterwards of trichlor-
id. The mother-liquor distilled with phosphoric anhydride, which decomposes
c acid, yields a distillate of acetic acid, and then, on changing the receiver, of
cetic acid, which soon solidifies to a crystalline mass. Lastly, the crystals
for some hours in vacuo on several sheets of white blotting paper, so that the
acetic acid may soak into the paper. (Dumas.)

oluble chloral is treated with fuming nitric acid, and the action, which is at
nded with evolution of heat and abundant evolution of red fumes, is afterwards
by the application of a gentle heat, till the flakes of insoluble chloral have com-
isappeared; the greater part of the excess of nitric acid is then distilled off;

and the remaining portion is left to evaporate in vacu
of potassium. Crystallised trichloracetic acid then
and oxalic acid, but generally retaining traces of chlo

3. When dichloride of carbon, C^2Cl^4, is placed in
covered with a film of water, and exposed to the su
an aqueous solution of trichloracetic acid, which ma
state by evaporation in vacuo over oil of vitriol and l

4. Chloraldehyde is dissolved in water; and the solu
is evaporated in vacuo over oil of vitriol and hydrat
acetic acid is obtained in beautiful crystals. (Mala

Properties.—Trichloracetic acid forms colourless
46° C., and in cooling begins to solidify at 45°; if th
perature rises to 46°, which is therefore the melting
a density of 1·617 at 46°, that of water at 15° being
200° without any decomposition, and sublimes in the
density = 5·3, by calculation 5·637, the difference ar
The acid has a faint odour at ordinary temperatures,
it emits a pungent and suffocating odour. It has a c
tongue white, like peroxide of hydrogen. It destroy
on the following day, and if left for some time or
reddens litmus strongly, but does not bleach it, ev
deliquesces in the air and dissolves readily in water.

Decompositions.—1. When the acid is heated with
distils over unchanged, and crystallises in rhombo
hydrochloric acid, carbonic anhydride, and carbonic o
manner: $C^2HCl^3O^2 + H^2O = 3HCl + CO + CO$
excess of *potash-solution*, ebullition takes place, con
removed from the fire; the first products of the act
of potassium; but on further boiling with the alkalin
into formate and chloride of potassium. (Dumas.)–

$$C^2HCl^3O^2 + K^2O = CHCl^3$$

then: $$CHCl^3 + 2K^2O = CHKO^2$$

When the acid is boiled with baryta-water, carbon
chloroform evolved (Dumas).—3. The acid boiled
solved into carbonate of ammonium, which sublimes,
as an oil (Dumas):

$$C^2HCl^3O^2 + (NH^4)^2O = (NH^4)^2.$$

4. Aqueous trichloracetic acid, or either of its salts
by *potassium-amalgam* (1 pt. potassium to 150 pts.
and reconverted into acetate of potassium (Melse
excess in proportion to the acid, no hydrogen is evo
or potassium alone, or zinc with sulphuric acid, do
but causes an evolution of hydrogen gas (Melsens).
only 3 at. be used in the form of potassium-amalgam
apparently an acid containing a smaller quantity of
5. *Zinc* dissolves in aqueous trichloracetic acid, and
a zinc-salt which appears to contain dichloracetic
acid is also reduced to acetic acid in the galvanic cir
carbon battery, with electrodes of amalgamated zinc.

TRICHLORACETATES.—Trichloracetic acid is
formula of its salts being $C^2MCl^3O^2$.

Trichloracetate of Ammonium. $C^2(NH^4)Cl^3$
saturated with ammonia, and evaporated at ordina
or in the air, yields crystals (Dumas). The salt is
acetamide is brought in contact with aqueous am
(Malaguti, Cloez). It crystallises in beautiful pri
at 80°; boils between 110° and 115° C., giving off va
bonate of ammonium, the latter appearing in peculiar
at 160° in yellowish, micaceous scales of anhydrou
which are tasteless, dissolve readily in water, and giv
potash, even in the cold. At a higher temperature, t
into carbonic oxide, phosgene, and sal-ammoniac vapo

Decomposition of the crystallised salt:

$$C^2(NH^4)Cl^3O^2 + 2H^2O = CHCl^3 + N$$

osition of the anhydrous salt:

$$C^2(NH^4)Cl^3O^2 = CO + CCl^2O + NH^4Cl.$$

oracetate of Potassium. $2C^2KCl^3O^2 + H^2O$.—The aqueous acid neu-
th carbonate of potassium yields by spontaneous evaporation, silky needles,
ompose with a kind of detonation when gently heated, and absorb only a
ntity of water when exposed to damp air. (Dumas.)
rium and *Calcium salts* are neutral and dissolve very readily in water.

oracetate of Silver. $C^2AgCl^3O^2$.—Recently precipitated oxide of silver
in the aqueous acid is converted into grey laminæ which dissolve in a larger
f water, and crystallise therefrom by evaporation in vacuo over oil of vitriol
dark, in crystalline granules and laminæ. The salt is very readily decom-
ight. When heated on a sheet of paper, it detonates violently, giving off
odour as trichloracetic acid when it evaporates, and leaves vegetations of
ide of silver. If it be moistened with alcohol and the alcohol set on fire, it
s more quietly, and without projection. (Dumas.)
oracetate of Ethyl. Trichloracetic Ether. $C^2Cl^3O^2.C^2H^5$.—Obtained
distilling trichloracetic acid with alcohol and a small quantity of sulphuric
nas), or by gradually adding chloraldehyde to alcohol. (Malaguti.)

$$\underset{\text{Chloral-dehyde.}}{C^2Cl^4O} + C^2H^6O = C^2Cl^3O^2.C^2H^5 + HCl.$$

duct obtained by either of these processes is precipitated by water, washed
r, and dried over chloride of calcium. It is a colourless oil, smelling like
t. Specific gravity 1·367. Boiling point 164°. Vapour-density 6·64.
potash decomposes it, forming alcohol and trichloracetate of potassium:

$$C^2Cl^3O^2.C^2H^5 + KHO = C^2H^6O + C^2Cl^3KO^2.$$

ia converts into trichloracetamide, $N.H^2.C^2Cl^3O$ (p. 22).
d to the action of chlorine in daylight, and in direct sunshine, it yields the
ucts as acetate of ethyl (p. 22). It is isomeric with the compound obtained
dry chlorine through dichloracetic ether contained in a vessel, the upper
hich is protected from the light. The two compounds are distinguished
other by their behaviour with potash, the latter yielding, not trichloracetate
m, but chloride of potassium, deliquescent chlorinated potassium-salts, and
ly liquid no longer decomposible by potash. (Leblanc.)
her chlorinated compounds produced by the action of chlorine on acetate of
be regarded as compounds of trichloracetic acid with ethyl in which the hy-
more or less replaced by chlorine: thus tetrachloracetic ether $C^4H^4Cl^4O^2$
$.C^2H^4Cl$; perchloracetic ether, $C^4Cl^8O^2 = C^2Cl^3O^2.C^2Cl^5$. All these com-
ndeed, when treated with potash, yield trichloracetate of potassium, *e.g.*:

$$C^4Cl^8O^2 + 2KHO = 2C^2Cl^3KO^2 + 2HCl.$$

hem however appear to be susceptible of isomeric modifications.
oracetate of Methyl. $C^2Cl^3O^2.CH^3$.—Obtained by processes exactly
those which yield the ethyl-compound, viz. by distilling the acid with wood-
sulphuric acid, or by the action of wood-spirit on chloraldehyde. It is a
oil, heavier than water, and smelling like peppermint. It is isomeric with
und $C^3H^3Cl^3O^2$, obtained by the action of chlorine on acetate of methyl. The
ounds are not however identical; for the former is converted by potash into
cohol and trichloracetate of potassium (together with formate and chloride
um resulting from the further action of the potash, p. 45); the latter when
th potash yields chloride and formate of potassium, together with chlorome-
HCl. (Laurent, see p. 23.)
racetate of methyl exposed to the action of chlorine in sunshine, is converted
loromethylic acetate, $C^3Cl^6O^2$, a compound also produced by the continued
chlorine on acetate of methyl.

RACETONES. See ACETONE (p. 29).

RACETONITRILE. See ACETONITRILE (p. 33).

RACETYL. C^2H^2ClO.—The radicle of chloracetic acid, chloracetamide, &c.
racetyl, C^2Cl^3O, is the radicle of trichloracetic acid, trichloracetamide, chloral,
yde, chloralide, &c.

RACETYPHIDE. *Trichloracephosphide. Phosphide of Trichloracetyl and*
$C^2H^2Cl^3PO = P.H^2.C^2Cl^3O$.—This compound, the analogue of trichlor-
, is produced by the action of chloride of trichloracetyl on phosphoretted
:

$$C^2Cl^3O.Cl + PH^3 = HCl + P.H^2.C^2Cl^3O.$$

also, together with oxychloride of carbon, when ph
heated perchloroformic ether:

$$C^3Cl^6O^2 + PH^3 = P.H^3.C^2Cl^3O$$

It forms small, white, crystalline scales, having
taste. It is permanent in the air at ordinary t
heated, leaving a carbonaceous residue containing
water; slightly soluble in alcohol, ether, and wood-
xvii. 309.)

CHLORAL. *Hydride of Trichloracetyl.* C^2H
discovered by Liebig in 1832 (Ann. Ch. Pharm
Dumas (Ann. Ch. Phys. [2] lvi. 123) and Städel
is the ultimate product of the action of chlorine up

$$C^2H^6O + Cl^8 = C^2HCl^3O$$

Probably the alcohol is first converted into aldeh
this compound 3H are afterwards replaced by 3
however, be obtained by the direct action of chlor
produced in the first instance, but is quickly conv
production of chloral from alcohol, it is absolutely
drous; if water is present, aldehyde, acetal, aceti
ducts are formed instead of chloral; these product
when the preparation is made with absolute alcoh
Chlorine, p. 74). Chloral is also produced by t
sugar. (Städeler.)

Fig. 127.

Preparation.—1. From alcohol. Pure and dry
alcohol contained in a tubulated retort having it
with a long
to the bulb,
extremity of
gases; the
tubulus. O
tube bent, a
tion being 2
inclination,
lower part, m
of considera
chlorine is best evolved from a mixture of commo
sulphuric acid (which gives it off more regularly tha
it must be passed first through a wash-bottle cont
phuric acid or over chloride of calcium, to dry it.
with hydrochloric acid gas and vapour of hydrochl
Woulfe's bottles, and thence into the open air, so th
by it. At the commencement of the operation, the
water, to prevent it from taking fire and deposit
absorption of the chlorine diminishes, and the liqu
be gradually heated, and at last nearly to the boili
require the passage of a rapid stream of chlorine
involving a consumption of about 1200 litres of
continually thicker, acquires a higher boiling po
heavy syrup, which, after standing for some days,
crystalline mass, consisting of hydrate of chloral
hydrochloric acid and undecomposed alcohol: *Cru*
of the liquid, after being agitated with four tim
set aside, does not in a few hours form a solid stra
oil of vitriol, the passage of the chlorine must
The solidified crystalline mass is heated till it
times its bulk of sulphuric acid, which does not
the dehydrated chloral has risen to the top of the
be accelerated by gentle heating; and the trans
immediately decanted by means of a pipette. If
it is particularly necessary to decant as quickly
thereby converted into insoluble chloral. Lastly,
which has been slaked and subsequently ignited,
being taken to keep the whole of the lime below
otherwise decompose the vapour and become red
is obtained tolerably pure; but it still contains

moved by repeated treatment with sulphuric acid, the chloral being each
led over lime. All these operations must be performed in well closed vessels.

istilling starch or sugar with hydrochloric acid and peroxide of manganese
r). 1 pt. of starch, or grape-sugar, or common sugar, is gently heated with
ommercial hydrochloric acid free from sulphurous acid and diluted with an
me of water, till the paste (formed when starch is used) has become fluid;
when cold, is introduced, together with 3 pts. of manganese and a small
f common salt (to fix the sulphuric acid produced from the sulphurous acid
mercial hydrochloric acid) into a capacious flask, in which it is heated as
possible to the boiling point; and the fire is then completely removed. The
s up, giving off a large quantity of carbonic acid, and continues to boil
time by itself. As soon as the ebullition slackens, it must be kept up by
cation of heat, and the distillate collected, as long as it becomes turbid when
h tolerably strong potash-ley (in consequence of separation of chloroform
hloral). More hydrochloric acid is then repeatedly introduced into the flask
ortions, till the distillate no longer smells of chloral, or becomes turbid with
he watery distillate is carefully freed from the colourless oil-drops, heavier
and smelling of chloroform, which are produced at the beginning of the
; and saturated with common salt, in order to raise its boiling point and
water. It is then redistilled, and the resulting distillate is freed from a
llow very pungent oil, and distilled several times more with common salt,
ops being each time removed, in order to obtain aqueous chloral as concen-
ossible, and as free as possible from the yellow oil, which greatly impedes
ation.

oval of this oil is facilitated by saturating the distillate, before each rectifi-
h chalk, which decomposes the oil, but does not attack the chloral. The
ed solution of chloral is saturated with dry chloride of calcium, and dis-
oil-bath at 120° C. Hydrate of chloral then passes over, as a colourless
ich solidifies in the receiver into a crystalline mass. The last portions of
ate are contaminated with a brown oily substance. 1. From the hydrate
thus obtained, the anhydrous chloral may be separated by distillation, and
the manner above described. (Städeler.)

es.—Chloral is a thin colourless oil, greasy to the touch, and making grease-
per, which, however, soon disappear. Specific gravity = 1·502 at 18° C., 1·518
03 at 22°. Boils at 94·4° (Liebig); at 98·6 when the barometer stands at
Kopp), and distils without decomposition. Vapour-density = 5·13. It has a
ngent odour, and excites a copious flow of tears: its taste is greasy and slightly
It acts very strongly on the skin, especially when its boiling vapour comes
therewith. It has no acid reaction, even when dissolved in water, and does
itate a solution of silver.

ith a small quantity of water, it becomes heated and solidifies, forming a
ystals of *hydrate of choral*, $C^2HCl^3O.H^2O$: a larger quantity of water dis-
nd the solution evaporated in vacuo deposits the hydrate of chloral in large
minæ. The hydrate volatilises gradually in the air, and distils without
tion when heated. Its vapour-density is 2·76.

dissolves also in alcohol and in ether. It absorbs chlorine gas without
nge, and readily dissolves iodine, bromine, sulphur, and phosphorus, especi-
heated. The iodine-solution has a purple-colour.

sitions. — 1. Chloral is under certain circumstances inclined to pass into
c insoluble modification (p. 64).—2. Anhydrous chloral distils, for the most
nged, with *strong sulphuric acid;* but when hydrate of chloral is heated
acid, part of the chloral distils over in the anhydrous state, while the rest is
into *chloralide* (p. 61), with evolution of hydrochloric and sulphurous
a trace of carbonic acid. This reaction serves for the detection of chloral
The liquid, concentrated by several distillations over chloride of calcium,
or some time, with six times its volume of strong sulphuric acid, to 125° C,
d, after cooling, with six measures of water. Chloralide then separates out
h carbonaceous particles; and the mixture washed, pressed between paper,
with ether and evaporated, yields crystals of chloralide, which may be
rified by heating with sulphuric acid and recrystallisation from ether.—
nitric acid, if ultimately aided by heat, converts chloral into trichloracetic
same transformation is effected by a mixture of hydrochloric acid and
f potassium.—4. *Anhydrous metallic oxides,* such as baryta, strontia, lime,
le, mercuric oxide, and peroxide of manganese, exert no action upon chloral,
liquid is distilled over them. If, however, in the distillation of chloral over

baryta, strontia or lime, a portion of the oxide is left
is heated in chloral vapour merely to 100°, it beco
composes the choral, with evolution of carbonic o
lic chloride mixed with charcoal.—*5. Alkalis*, eith
or of aqueous solutions, decompose chloral readily
evolution of heat, converting it into formate of potass
of the latter compound is further decomposed, yield
sium:

$$\underset{\text{Chloral.}}{C^2HCl^3O} + KHO = \underset{\text{Formate of potassi}}{CHKO}$$

and $$CHCl^3 + 4KHO = CHKO^2 +$$

—5. Vapour of chloral passed over *red-hot iron* yi
of iron mixed with charcoal.—6. *Potassium*, in contac
and forms a resinous body from which water extrac
—7. Chloral forms with *ammonia* a compound, whic
silver in the specular form, and from which sulphydr
compound apparently analogous to thialdine (Stä
— 8. *Sulphydric acid gas* passed through an aque
a sparingly soluble crystalline compound, which is
captan (p. 107), but decomposes much more easil
during drying (Städeler). — 9. By boiling hyd
and *hydrochloric acid*, a syrupy acid is formed re
three reactions indicate a close analogy between chl
strengthened by the fact that chloral forms crystall
of alkali-metal. (Städeler.)

Insoluble Chloral, *Metachloral* (Gm. viii. 2
verted, under certain circumstances, into an isomer
This change takes place spontaneously when chl
bottle, or when it is placed in contact with a quanti
vert it into the hydrate. Metachloral thus prepare
position as chloral. It is also produced, mixed,
by the action of sulphuric acid upon chloral. A la
obtained in the preparation of chloral from alco
strong sulphuric acid, solidifies in a few hours into
chloral in contact with six times its volume of str
same transformation in the course of a night. The
purified from chloralide by pulverising, and washing
alcohol.

Metachloral is a white powder, greasy to the to
odour. It volatilises slowly in the air or in vacuo.
and ether. When perfectly dry, it is reconverted by
according to Kolbe, above 200° according to Regna
it partly distils over as soluble chloral, but a co
with formation of chloralide, and evolution of hydr
fuming nitric acid, metachloral is, like chloral, conve
is not attacked by a mixture of hydrochloric acid
solutions of the caustic alkalis, it behaves like ord
formate and chloroform; but the quantity of the l
concentrated.

CHLORAL, AMYLIC. See CHLORAMYLAL.

CHLORAL, MESITIC. This name was ap
473) to a pungent vesicating liquid of specific gr
which is obtained by passing dry chlorine into ac
per cent. chlorine; Liebig found only 52·6 per cen
taining two or more of the chloracetones (p. 29).

CHLORAL, PROPIONIC. *Hydride of Pen*
body is found amongst the products obtained by di
hydrochloric acid and peroxide of manganese. On
chalk or carbonate of sodium, and rectifying over a s
the propionic chloral passes over among the first p
remove the latter, the rectified distillate is agitated
and the cold saturated solution is decanted and
separating in heavy drops having a faint yellow
through a small quantity of water, and exposing

ables are obtained, which may be purified from adhering oil by pressure pulous paper. They consist of a hydrate containing 4 at. water: $C^8HCl^4O^2$. tädeler, Handw. d. Chem. Suppl. ii. 796.)

ALBIN. $C^6H^6Cl^2$.—A crystalline substance contained in trichlorophenic ed by passing chlorine through coal-tar. It is separated by treating the with ammonia and alcohol, or better with ether, whereupon the chloralbin very white needles; it may be further purified by dissolving it in boiling s but sparingly soluble in boiling alcohol, and insoluble in alkalis. It boils and crystallises on cooling in fern-like tufts. At a higher temperature, without alteration and crystallises in needles. It is not attacked by hot lphuric acid. (Laurent, Rev. scient. vi. 72.)

ALDEHYDES. These compounds are aldehydes in which the hydrogen less replaced by chlorine, and may be regarded as derived from the cor- acids by the substitution of 1 or more at. chlorine for an equivalent quantity of hydrogen HO, thus:

	Chloraldehydes.	Acids.
Acetic	$C^2H^3O.Cl$	$C^2H^3O.HO$
Trichloracetic . . .	$C^2Cl^3O.Cl$	$C^2Cl^3O.HO$
Nitric	$NO^2.Cl$	$NO^2.HO$
Sulphuric	$(SO^2)''.Cl^2$	$(SO^2)''.(HO)^2$
Phosphoric	$(PO)'''.Cl^3$	$(PO)'''.(HO)^3$

oraldehydes are a more numerous class of compounds than the alde- selves, including many compounds usually denominated oxychlorides, oride of phosphorus. They bear to their corresponding acids the same at metallic chlorides bear to metallic hydrates.

chloraldehyde is also specially applied to the second compound in the viz:

le of Trichloracetyl or *Perchlorinated Acetic Aldehyde*, $C^2Cl^4O =$ –This body, discovered by Malaguti (Ann. Ch. Phys. i. [2] xvi. 5); Gm. erh. i. 756), is a constant product of the action of heat on the perchlorinated nic) ethers. Thus:

$$C^4Cl^{10}O = C^2Cl^4O + C^2Cl^6.$$

Perchlor. oxide of ethyl. — Sesquichloride of carbon.

$$C^3Cl^6O^2 = C^2Cl^4O + COCl^2.$$

Perchlor. formate of ethyl. — Oxychloride of carbon.

$$C^4Cl^8O^2 = 2C^2Cl^4O$$

Perchlor. acetate of ethyl.

$$C^5Cl^{10}O^3 = C^2Cl^4O + C^2Cl^6 + CO^2.$$

Perchlor. carbonate of ethyl.

$$C^6Cl^{10}O^4 = 2C^2Cl^4O + COCl^2 + CO.$$

Perchlor. oxalate of ethyl.

st prepared from perchlorinated oxide of ethyl, $C^4Cl^{10}O$ (the product ob- the continued action of chlorine in sunshine, on anhydrous ether). This is resolved at 300° C. into chloride of trichloracetyl and trichloride of nd by subjecting the mixture to repeated fractional distillation, the tri- carbon is left behind, and the chloride of trichloracetyl is obtained pure. cation must be continued till the distillate no longer shows any turbidity d with water.

ehyde is a transparent, colourless liquid, of specific gravity 1·603 at 18° C. nt 118°. Vapour-density 6·32 (calc. 2 vol. 6·295). It gives off excessively pours on exposure to the air, and when placed on the tongue, first excites a f dryness, then forms a white spot, and ultimately exerts a caustic action. litmus after a few seconds.

in water, and gradually dissolves, forming a clear solution of hydrochloric racetic acids: the same decomposition is produced by aqueous solutions of lkalis:

$$C^2Cl^3O.Cl + H^2O = HCl + C^2Cl^3O.H.O.$$

small quantity of alcohol is poured upon it, great heat is evolved, and the ickly volatilised; but if the chloraldehyde be slowly added to an excess of

alcohol, gradual decomposition takes place, attende
the products being hydrochloric acid and trichlorac

$$C^2Cl^3O.Cl + C^2H^5.H.O = HCl$$

With ammonia it forms trichloracetamide (p. 22

$$C^2Cl^3O.Cl + 2NH^3 = N.H^2.C$$

and with phosphoretted hydrogen, PH^3, the ana
$P.H^2.C^2Cl^3O$ (p. 879).

CHLORALIDE. $C^6H^2Cl^6O^3$. (Städeler, An
ibid. cv. 293.)—A crystalline compound obtained
hydrate of chloral. To prepare it, hydrate of ch
times its volume of strong sulphuric acid, the mi
distilled at a heat between 120° and 130° C., as lo
pass over. This choral is reconverted into hydrate
poured back, and the distillation is repeated till
decomposed. The sulphuric acid is then found t
liquid, which solidifies on cooling into a white cry
up, the sulphuric acid is drained off, and the cryst
wash-water no longer reddens litmus; they are the
dissolved in ether, and the ethereal solution is
The chloralide then separates as the ether evapora
must be crystallised several times from a mixture
them from an oily matter which adheres to them:
Pharm. cv. 293), a purer and more abundant pr
fuming sulphuric acid on hydrate of chloral. W
distilled over ordinary sulphuric acid, is mixed wi
quantity of hydrochloric acid is evolved, and abo
verted into chloralide. Carbonic oxide is also gi
very small quantity of carbonic anhydride; sulphu
the end of the process. The oily distillate solidi
which may be purified by recrystallisation from bo

Kekulé explains the formation of chloralide and
following equation:—

$$3C^2HCl^3O + H^2O = C^6H^2Cl^6O$$

Städeler, on the other hand, considers it improba
into chloralide can be due to the action of water,
seems to act better than ordinary sulphuric acid.
of chloral (insoluble chloral) splits up into chlorali
equation:

$$3C^2HCl^3O = C^6H^2Cl^6O^3$$

and attributes the evolution of carbonic oxide obe
of a molecule of chloral into this gas and chlorofor

$$C^2HCl^3O = CO + C$$

Chloralide is insoluble in water, and likewise in su
in cold alcohol, but easily in boiling alcohol and i
coholic solution, it is deposited in very delicate
alcohol and ether, in stellate groups of rectangular
system, with oblique terminal faces, and generally
They are transparent and colourless, with a glassy
direction parallel to the prismatic faces. Chlorali
to an oily liquid, emitting at the same time an odo
at 108° (Kekulé). Chloralide burns at 200° (St
a bright flame, green at the edges.

The alcoholic solution of chloralide does not
adding a drop of ammonia, a precipitate is immedi
of silver. Chloralide immersed in aqueous pota
formate of potassium; but if alcoholic solutions are
and chloride of potassium, these compounds bein
alcoholic potash upon chloroform.

The composition of chloralide has been variously
deler, who discovered it, assigned to it the formu
the recent experiments of Kekulé. Gerhardt (T
$C^6H^2Cl^7O^4$; Gmelin (*Handbook.* ix. 207) gave C^6H
der Chemie, 2^{te} Aufl. i. 112, the formula $C^4HCl^3O^2$ i

owing table exhibits the calculated composition of chloralide, according tc
ng formulæ, as compared with the results of analysis:

	Calculation according to:				*Analysis:*	
	Städeler.	Gerhardt.	Gmelin.	Handw.	Städeler.	Kekulé.
	$C^6H^2Cl^6O^6$	$C^6H^2Cl^7O^4$	$C^6H^4Cl^{10}O^6$	$C^4HCl^3O^2$		
					mean	mean
.	18·61	18·50	17·98	18·55	18·64	18·64
.	0·62	0·77	0·39	0·75	0·77	0·72
.	65·88	64·10	68·62	66·29	66·20	66·00
.	14·89	16·63	12·44	14·98		
	100·00	100·00	100·00	100·00		

RALOÏL. A product of the action of chlorine upon aloin (p. 148).

RALURIC ACID. An acid produced, together with other substances, by
of chlorous acid on uric acid. It crystallises in nacreous laminæ; forms
ble salts with barium and lead, and a curdy precipitate with silver-salts.
y analysis 27·3 per cent. C, 3·8 H, 28·1 N. and 11·4 Cl, numbers which
imately represented by the formula $C^{14}H^{22}N^{12}Cl^2O^{11}$. (Schiel, Ann. Ch.
i. 78.)

RAMYLAL. C^5H^9ClO (?) — A heavy liquid produced by the action of
on amylic alcohol (*q. v.*)

RANIL. Syn. with PERCHLOROQUINONE, $C^6Cl^4O^2$. (See QUINONE.)

RANILAMIC ACID. Syn. with DICHLOROQUINONAMIC ACID. (See
CID).

RANILAMIDE. Syn. with DICHLOROQUINONAMIDE. (See QUINONIC

RANILAMMONE. Syn. with DICHLOROQUINONAMATE OF AMMONIUM.

RANILIC ACID. Syn. with DICHLOROQUINONIC ACID. (See QUINONIC

RANILINE. Syn. with CHLOROPHENYLAMINE. (See PHENYLAMINE.)

RANISIC ACID. See ANISIC ACID (p. 302).

RASTROLITE. A mineral found on the shores of Isle Royale, Lake
n small rounded water-worn pebbles which have come from the trap. It
y radiated or stellate structure, light bluish-green colour, and pearly lustre
atoyant on the rounded sides. Specific gravity 3·180. Hardness 5·5—6.
y Whitney:

Al^2O^3	Fe^2O^3	CaO	Na^2O	K^2O	H^2O	
25·49	6·48	19·90	3·70	0·40	7·22	= 101·18
24·25	6·76	21·68	4·88		5·77	= 100·25

bers lead to the formula—

$$3\left[\left(\left\{\begin{matrix}\tfrac{2}{3}Ca''O\\ \tfrac{1}{3}Na^2O\end{matrix}\right.\right)^2.SiO^2\right] + 2\left[\left(\left\{\begin{matrix}\tfrac{2}{3}Al^2O^3\\ \tfrac{1}{3}Fe^2O^3\end{matrix}\right.\right)^2.3SiO^2\right] + 6H^2O.$$

I = Ca, Na and $m = \tfrac{2}{3}$ (Al, Fe), may be reduced to that of an orthosilicate,
$)^{12}$ + 2aq.

eral gives off water when heated, and melts with intumescence before the
o a greyish blebby glass. With borax it forms a transparent glass tinged
blue with cobalt solution. Dissolves in hydrochloric acid, with separation
t silica. (Dana, ii. 315.)

RATES. Chloric acid, $HClO^3$, is monobasic and forms but one class of
ng the general formula $MClO^3$ or $M''(ClO^3)^2$. They are all soluble in
are resolved by heat into oxygen and a metallic chloride. (See CHLORIC
r CHLORINE, p. 910.)

ATE OF ALUMINIUM is a deliquescent salt obtained by precipitating a
silico-fluoride of aluminium with an equivalent quantity of potassium, and
g the filtrate. (Berzelius.)

ATE OF AMMONIUM is obtained by adding ammonia or the carbonate to
d; by precipitating an earthy chlorate with carbonate of ammonium; or by
ely divided chlorate of potassium by small portions to a solution of silico-
ammonium, and filtering. It crystallises in slender needles, has a pungent
odes when heated, and sometimes, according to Mitscherlich, even at ordinary
res. Dissolves easily in water and in alcohol.

ATE OF BARIUM, $Ba''(ClO^3)^2$.—Prepared: 1. By saturating aqueous chloric
aryta-water or carbonate of barium. *a.* A hot solution of chlorate of potassium

is precipitated with hydrofluosilicic acid in slight
with carbonate of barium, whereupon chlorate of ba
of silico-fluoride of barium remains behind. The
the chlorate by evaporation (Wheeler, Ann. Ch
of 27 pts. chlorate of sodium in 54 pts. water is m
taric acid in 88 pts. water; the mixture is thrown
alcohol; and the liquid, after standing 24 hou
tartrate of sodium, then saturated with carbonate o
xxiii. 306.) *c.* Equivalent quantities of chlorate
ammonium (122·6 pts. of the former to 167 of the
possible quantity of boiling water; the liquid, afte
crystallised out, is mixed with an equal quantity of
boiling with carbonate of barium, &c. (L. Thom
p. 381.)

2. By passing chlorine into hot water in which
dissolved. Chloride and chlorate of barium are t
chloride is suffered to crystallise out, and the rest
silver to the solution, in the exact quantity req
Gmelin's Handbook, ii. 161.)

Chlorate of barium forms hydrated prismatic cry
the monoclinic system. Ratio of orthodiagonal,
0·882 : 1 : 1·07. Inclination of axes = 85° 30';
tion =97°; [P ∞] : [P ∞], in the clinodiagonal
bination ∞P . [P ∞] . −P ∞; also without −P ∞;
graphie, p. 304), and less frequently with 0P (Ra
The crystals are transparent and colourless, give
120° C., oxygen at 250°, and melt at a tempera
Ch. Pharm. lii. 231; Souchay, *ibid.* cii. 381).
combustible bodies; produces a green flame when h
emits a bright flashing light with strong sulphuri
easily in water, but is insoluble in alcohol. The
pts. of water at 0° C., in 2·70 pts. at 20°, in 1·92
1·02 pts. at 80°, and in 0·79 pts. at 100° (Kre
p. 274.) According to Hutstein (Arch. Pharm
crystallising.

Chlorate of Calcium, $Ca''(ClO^3)^2 + 2H^2$
Crystallises in deliquescent rhomboïdal prisms.
They contain 16·5 p. c. water, melt in their wa
heated, and decompose at a higher temperature.

Chlorate of Cobalt, $Co''(ClO^3)^2 + 6H^2O$
Decomposed by ignition into chlorine, oxygen, a
chloride of cobalt. (Wächter, Ann. Ch. Pharm.

Chlorate of Copper, $Cu''(ClO^3)^2 + 6H^2$
chloric acid yields green deliquescent octahedron
soluble in alcohol. At 100° C. it gives off a f
further decomposition, leaving a residue which i
acids, and appears to consist of a basic chlorate,
acid gives no precipitate with silver-salts. (Wä
detonates with bright green flame on glowing co
for the production of green fire.

Chlorate of Lead, $Pb(ClO^3)^2 + H^2O$.—Rho
and opaque by exposure to the air; soluble in wat
When heated, they leave oxychloride of lead conta

Chlorate of Lithium, $2LiClO^3 + H^2O$.—Radia
at 0° C., and giving off water at 140°, together wi
chlorine. Very soluble in alcohol. (Wächter.)

Chlorate of Magnesium, $Mg''(ClO^3)^2 + 6H$
in alcohol, melting at 40° C., and giving off
Wächter.)

Chlorate of Manganese.—Colourless, kno

Chlorates of Mercury.—The *mercuric* sal
oxide in warm chloric acid (Vauquelin), or by h
sive portions of chlorine-water, filtering from merc
the filtrate; mercuric chloride then crystallises c
solution (Braamcamp and Siqueira.) Mercuri

rhich redden litmus, taste like the chloride, and are resolved by heat into
ıs, mercurous chloride, calomel, and metallic mercury. The salt does not
on red-hot coals, but sets fire to sulphide of antimony at ordinary tempera-
Gm. vi. 62.)

rous Chlorate, $Hg^2O.Cl^2O^5$ or $(Hg^2)''(ClO^3)^2$.—A solution of mercurous
chloric acid yields the salt in beautiful prismatic crystals, which dissolve in
d in alcohol, and are resolved by heat into oxygen, metallic mercury, and
(Wächter.)

RATE OF NICKEL, $Ni''(ClO^3)^2 + 6H^2O$, crystallises in regular octahedrons of a
en colour, deliquescent and soluble in alcohol. When heated, they give off
nd chlorine, and leave a mixture of chloride and oxide of nickel; at a very
d heat, however, nothing but oxide remains behind. (Wächter.)

RATE OF POTASSIUM, $KClO^3$, or $KO.ClO^5$.—This salt is an important
manufacture, being used in the preparation of lucifer matches and for other
in the arts. It is prepared, either by passing chlorine into solution of potash
ate of potassium, whereby chlorate and chloride of potassium are formed,
e separated by crystallisation, the chlorate being much the less soluble of the
by decomposing chlorate of calcium with sulphate or chloride of potassium.

olution of 1 pt. hydrate of potassium in 3 pts. water is saturated with chlo-
whereby chloride and hypochlorite of potassium are produced, the liquid
strong bleaching properties:

$$2KHO + Cl^2 = KClO + KCl + H^2O.$$

d is then left to itself for a day, or heated for some time to the boiling point,
the hypochlorite is completely resolved into chloride and chlorate:

$$3KClO = 2KCl + KClO^3.$$

nate result is to convert 6 at. hydrate of potassium, by the action of 6 at.
into 1 at. $KClO^3$ and 5 at. KCl. It has been found that if a solution of
ither stronger or weaker than that above mentioned be used, part of the
produced is decomposed into free oxygen and chloride of potassium.

lution, when left to itself, deposits the greater part of the chlorate of potas-
crystals, which may be purified from adhering chloride by recrystallisation.
her-liquor yields by concentration an additional quantity of chlorate, which,
is more contaminated with chloride, and requires a greater number of crystal-
to purify it. The test of purity is that the solution is not clouded by a drop
of silver.

nate of potassium may be used for the preparation instead of caustic potash.
ase a considerable quantity of acid carbonate of potassium is formed in the
ge of the process, and crystallises on the sides of the vessels; but on continuing
age of the chlorine, this salt is decomposed, with evolution of carbonic acid,
nate products being chlorate and chloride of potassium as before.

nate of potassium may also be used in the solid form, being laid on shelves or
a chamber into which chlorine gas is introduced, just as in the manufacture
ning powder. When the absorption of the chlorine is complete, the product
ved in water, and the chlorate crystallises out, as above described.

pochlorite of calcium, or bleaching powder, the so-called "chloride of lime"
into a "cream" with water, and submitted to continuous boiling or evapora-
dryness, whereby it is resolved into a mixture of chlorate and chloride of
(p. 910), a change the completion of which is indicated by the loss of bleach-
erties in the mass. The residue, after evaporation, is treated with water, and
or sulphate of potassium is added, whereby the chlorate of calcium is de-
d, with production of chlorate of potassium and chloride or sulphate of calcium.
rate, amounting to about $\frac{1}{10}$ of the weight of chloride of lime employed, is
d from sulphate of calcium by the insolubility of the latter, or from chloride
m by crystallisation.

rocess now generally employed consists in a modification of the last, in which
ide of lime is formed in the same operation as the chlorate itself, instead of
from a previously manufactured bleaching powder. Excess of chlorine is
nto a mixture of 300 pts. caustic lime and 154 of chloride of potassium with
er, the operation being performed in close leaden tanks, heated by steam and
with agitators. A man-lid, through which the tank can be cleansed or
and one or two wide tubes descending nearly to the bottom of the vessel,
which materials can be introduced, complete the arrangement. During the
ne temperature rises to about 200° F. After the completion of this operation,

the liquid is filtered and evaporated nearly to dryness
mass is redissolved in hot water and set to crystallise

The whole of the chloride of calcium remains in the
of chlorate are rendered fit for the market by slight
tion upon which this operation depends is represented

$$KCl + 3Ca''O + 6Cl = KClO$$

In this process, 154 pts. KCl give more than 200 p
of direct saturation, 115 pts. caustic potash yield
same time, no by-product is formed except chloride
mother-liquors of this manufacture consist, within
salt, and may be decomposed either by an addition o
bonate of sodium. In the former case, sulphate o
able in the manufacture of paper, while chloride
tion, and may be recovered by evaporation, to be em
portions of chlorate: in the latter, carbonate of calc
the druggist, is precipitated, and is largely employe
perfumer. Nearly the whole of the waste liquors o
converted into the latter product.

Carbonate instead of chloride of potassium may al
in that case, on treating the mixture with water, af
action of chlorine, the whole of the lime remains as ca
rate of potassium are dissolved. (Gm. iii. 59, *Ure's*
and Mines, i. 66.)

Properties.—Chlorate of potassium crystallises in
rarely in needles. The crystals belong to the mon
diagonal, clinodiagonal, and principal axis = 1·360 :
70° 11′. Ordinary combination ∞P . 0P . +P. +2
age parallel to ∞P and 0P.

Chlorate of potassium is but slightly soluble in col
by 100 pts. of water at different temperatures, as dete
in the following table:

at 0° C.	3·3 pts.	at 4
15·37°	6·03 „	7
24·43°	8·44 „	10
35·02°	12·05 „	

It is insoluble in absolute alcohol.

Chlorate of potassium is permanent in the air
easily decomposed by heat, being at first resolve
of potassium, with a small quantity of free oxygen
while at a higher temperature the whole of the ox
of its weight in all), and chloride of potassium rema

The decomposition is greatly facilitated by mixin
manganese or oxide of copper, the whole of the ox
given off at a low red heat without previous forma
ture is very convenient for the evolution of oxyge
undergo any alteration, appearing to act merely by d
rate and preventing them from fusing into a mass.

Chlorate of potassium is a powerful oxidising age
mixed with certain combustible bodies and struck o
with *flowers of sulphur*, it produces a series of shar
salt with *sulphide of antimony* takes fire when trit
A small quantity of the chlorate mixed with *phosp*
detonates with a loud report. These combustions
when large quantities are used.

Chlorate of potassium is decomposed by acids, with
chlorous acid, or hypochlorous acid. With *strong*
peroxide of chlorine, perchlorate, and acid sulphate o

$$3KClO^3 + 2H^2SO^4 = 2ClO^2 + KClO^4$$

The decomposition is attended with violent decrepita
ing light; combustible substances, such as sulphur
arsenic, sugar, gum, resin, &c., are inflamed by the
finely-divided mixture of chlorate of potassium and
heated to about 70° C. gives off peroxide of chlorine
while chloride and acid oxalate of potassium remain

. xi. 193). The reaction probably takes place in the manner represented by
ion:

$$KClO^3 + 6C^2H^2O^4 = 2C^2KHO^4 + KCl + 2ClO^2 + 8CO^2 + 5H^2O.$$

e of potassium boiled with *strong nitric acid* yields nitrate and perchlorate of
, with evolution of chlorine and oxygen, but no peroxide of chlorine.
J. pr. Chem. xxiii. 296):

$$8KClO^3 + 6HNO^3 = 6KNO^3 + 2KClO^4 + Cl^6 + O^{13} + 3H^2O.$$

ric acid free from nitrous acid does not act on chlorate of potassium, even
led; but if it contains *nitrous acid*, or if any reducing agent is present,
tartaric acid, or arsenious acid, a lower oxide of chlorine is produced.
nperature be kept below 5° C. the chief product is chlorous acid, $HClO^2$,
s acid being at the same time reconverted into nitric acid: $HNO^2 + HClO^3$
$+ HClO^2$ (**Millon**, Ann. Ch. Pharm. xlvi. 298). Chlorate of potas-
ed with hydrochloric acid, yields chloride of potassium, and gives off a mix-
roxide of chlorine and free chlorine, called *euchlorine*, having the proportional
on of hypochlorous anhydride ($ClO^2 + Cl^3 = 2Cl^2O$). The reaction is:

$$4KClO^3 + 12HCl = 4KCl + 6H^2O + 3ClO^2 + Cl^9.$$

of chlorate of potassium and hydrochloric acid is much used as an oxidising
. for the destruction of organic matter in toxicological investigations.

e of potassium heated with *pentachloride of phosphorus*, gives off a deep yellow
does not explode when heated, and when passed into dilute potash-ley,
oride, chlorate, and hypochlorite of potassium (**H. Schiff**, Ann. Ch. Pharm.
—Chlorate of potassium distilled with *iodine*, gives off a chloride of iodine,
oride and iodate of potassium remain mixed with the excess of chlorate
):

$$KClO^3 + I + I^x = KIO^3 + I^xCl.$$

id added to solution of chlorate of potassium, forms crystals of neutral or acid
potassium, while free chloric acid remains in solution. (**Serullas.**)

e of potassium is extensively used in the manufacture of lucifer matches and
. Lucifer matches which take fire by friction, are tipped with a mixture
e of potassium, phosphorus, and glue or gum.

es for producing fires of various colours, are composed as follows:

ed fire.		Green fire.		Purple fire.	
strontium	40 pts.	Nitrate of barium	77 pts.	Oxide of copper	12 pts
f potassium	6 „	Chlor. of potassium	8 „	Chlor. potassium	30 „
coal	2 „	Fine charcoal	3 „		—
	13 „	Sulphur	13 „	Sulphur	12 „

lowing composition is applied to the interior of percussion caps, in quantities
om 0·2 to 0·3 of a grain. Chlorate of potassium 26 pts., nitre 30, fulminate of
2, sulphur 17, ground glass 14, gum 1 (= 100).

e of potassium is now extensively used as an oxidising agent in heightening
ity of *steam-colours* on printed goods. It is of constant use in the laboratory
e of oxygen, and is employed in medicine in the treatment of irritation of
us membranes. For the manufacture of gunpowder it is not well adapted,
wder made with it, produces a very violent explosive force within a small
, and bursts the gun instead of propelling the ball.

ATE OF SILVER, $AgClO^3$.—Obtained by dissolving oxide of silver in
id, or by passing chlorine through water in which the oxide is suspended,
rom chloride of silver, and evaporating. It crystallises in white opaque
prisms, with oblique terminal faces (**Vauquelin**), of specific gravity 4·430
er); tastes like the nitrate. It deflagrates brightly on hot coals, and when
th sulphur, detonates violently on the slightest pressure. Hydrochloric,
acetic acid, convert it into chloride, with evolution of oxygen.

ATE OF SODIUM, $NaClO^3$.—This salt may be prepared by the action of chlo-
lution of soda; but it is difficult to separate from the chloride formed at the
; the separation might, however, be effected by alcohol, which dissolves the
uch more easily than the chloride. The salt is likewise obtained by decom-
orate of potassium with silico-fluoride or acid tartrate of sodium, or chlorate
ium by carbonate of sodium (**Wittstein**). It might also be prepared by
ng chlorate of calcium with carbonate of sodium.

e of sodium crystallises in regular tetrahedrons, modified by the faces of the
etrahedron, also of the cube and rhomboïdal dodecahedron: the crystals are

isomorphous with those of bromate of sodium. Th
of cold water, and in a smaller quantity of boiling w
alcohol at 16° C. and in a smaller quantity of hot al

Chlorate of Strontium, $Sr''(ClO^3)^2$.—Pre
tallises in deliquescent needles, or, according to Wä
It decomposes at the same temperature as the bari
flame on glowing coals.

Chlorate of Uranium.—Protoxide of u
forming a green solution, which decomposes sponta
and formation of uranic chloride. (Rammelsbe

Chlorate of Zinc, $Zn''(ClO^3)^2 + 6H^2O$, is obta
or metallic zinc in chloric acid, chloride of zinc being
by passing gaseous fluoride of silicon into water in w
and boiling the filtered liquid with chlorate of pota
in octahedrons, has a very rough taste, and is solub

CHLORETHERAL. Syn. with Monochl
Oxide of (ii. 643).

CHLORHYDRIC or **HYDROCHLORIC A**
known compound of chlorine and hydrogen. Its so
very early times, and has received the names of *s*
chloric acid, and *chlorhydric acid*. The gas was di

Natural Sources.—Hydrochloric acid gas is e
and the acid solution is sometimes found in crevi
to the amount of 1 or 2 pts. in a thousand, in
which have their source in volcanic formations.

Formation and Preparation.—1. Hydrochloric ac
chlorine and hydrogen. A mixture of the two
violently if a burning body is introduced into it, o
it, or if it be exposed to direct sunshine (Gm. ii.
in the dark, but if the mixture be exposed to di
gradually. Thus, if two bottles of exactly equal c
grinding, are filled by displacement with chlorin
adapted to each other by their mouths, the chlo
and set aside for some hours in a light situation, b
colour of the chlorine will gradually disappear a
exposure to sunshine will complete the combinatio
rated under mercury, each will be found full of hy
and no rising of the mercury taking place in eith
and hydrogen have combined without expansion
tinged with blue litmus be thrown up into either o
and completely absorbed, while the litmus solutio
Any bleaching of the litmus would indicate free
presence of free hydrogen; in this manner, an e
mixture may be detected.

2. Hydrochloric acid gas is usually prepared by t
chloride of sodium. There is at first a copious eff
it may be necessary to revive by the application of

$$NaCl + H^2SO^4 = NaH$$

The gas must be collected over the mercurial tr
water.

3. Hydrochloric acid may also be produced b
chlorides. The two chlorides of phosphorus are
pletely by mixture with an excess of water, with f
phoric acid respectively, thus:

$$PCl^3 + 3H^2O = H^3PO^3$$
$$PCl^5 + 4H^2O = H^3PO^4$$

The two chlorides of antimony are decomposed m
requires prolonged treatment with water to effect
however, takes place readily at a boiling temper
boiling temperature, is decomposed very imperfectly.
and protochloride of magnesium, &c., are decomp
hydrochloric acid, at temperatures considerably bel

$$Al^2Cl^6 + 3H^2O = Al^2O^3$$
$$Mg''Cl^2 + H^2O = Mg''O$$

er, hydrochloric acid results from the reaction of chloride of phosphorus,
of antimony, and some other chlorides, usually hyperchlorides, not only with
ut with most oxyhydrogenised compounds (pp. 897—900).

ydrochloric acid is a constant attendant upon the direct action of chlorine on
nised substances. A solution of chlorine in water is converted, when exposed
into hydrochloric and hypochlorous acids: $Cl^2 + H^2O = HCl + HClO$. Chlorine
y decomposes sulphydric acid, with formation of hydrochloric acid and separa-
ulphur: $Cl^2 + H^2S = 2HCl + S$. Phosphoretted and arsenetted hydrogen are
decomposed by chlorine, with formation of hydrochloric acid. Numerous
compounds also are decomposed by chlorine, one portion of that element
with the whole or with part of the hydrogen, and an equal portion taking the
the hydrogen thus removed: *e. g.*

$$\underset{\text{Acetic acid.}}{C^2H^4O^2} + 3Cl^2 = \underset{\text{Trichlor-acetic acid.}}{C^2HCl^3O^2} + 3HCl.$$

loric acid also results from the inverse action of hydrogen upon a chlorine
nd, as when ignited chloride of nickel is subjected to a current of hydrogen,
$NiCl + H = HCl + Ni$.

rties.—Hydrochloric acid is a colourless gas, having a strong acid taste, and
nt irritating odour. Its specific gravity (air = 1) is, according to the deter-
n of Biot and Gay-Lussac, 1·27; by calculation, it is $\frac{35\cdot5 + 1}{2} \times 0\cdot0693 = 1\cdot265$.
opaque white fumes in the air, owing to its union with, and condensation of, the
eric moisture. In perfectly dry air these fumes are not produced. The gas is
ly soluble in water. When a flask of dry hydrochloric acid is opened under
he whole of the gas is absorbed in an instant, and the flask not unfrequently
by the violent rush of liquid. At mean temperature (15° C.) water dissolves
58 times its volume of the gas (see GASES, ABSORPTION OF). At the tempe-
f 10°, under a pressure of 40 atmospheres, hydrochloric acid is condensed into
less liquid, having a specific gravity 1·27. It has never been solidified. Hy-
ric acid is not inflammable, and extinguishes most burning bodies, but when a
potassium is introduced by means of an iron wire into a tube full of the gas
l over mercury, and is then heated to redness by a spirit-lamp applied exter-
undergoes combustion, unites with the chlorine, and leaves the hydrogen,
s eventually found to occupy exactly one half the volume of the original gas:
$K = KCl + H$.

ion of hydrochloric acid is usually made from common salt and sulphuric acid
with about two-thirds its bulk of water. The reaction is effected in a retort
h a gentle heat is applied, and the evolved gas is condensed in a vessel or
f vessels of distilled water. The condensing liquid increases considerably in
nd may eventually be made to acquire a specific gravity of 1·21, under which
tances it consists of one atom of hydrochloric acid, HCl, dissolved in three atoms
r, H^2O. Solution of hydrochloric acid has usually a specific gravity of 1·162,
n consists of one atom of hydrochloric acid HCl, dissolved in four atoms of
H^2O.

nercial muriatic acid is made by heating in iron cylinders two proportions of
salt, with as much brown sulphuric acid as contains one proportion of
d, and condensing the evolved gas in water contained in a series of stoneware
s bottles. The reaction is: $H^2SO^4 + 2NaCl = Na^2SO^4 + 2HCl$. For details,
's Dictionary of Arts, Manufactures and Mines, ii. 481.—Pelouze et Frémy,
de Chimie générale, 3me éd. i. 436.—Payen, *Précis de Chimie industrielle*, 4me éd.

commercial acid, which frequently contains, as impurities, sulphurous acid,
us acid, sesquichloride of iron, stannic chloride, and even free chlorine, may
ly purified by dilution and redistillation. A pure solution of hydrochloric acid
ly colourless, but when in large quantities, has a very pale yellowish green tint.
ght yellow colour of miscalled pure acid is generally due to the presence of
orine, but the bright deep yellow of the commercial acid results from the
e of chloride of iron. The introduction of a small quantity of organic matter,
ntact with a cork, will likewise impart a yellow colour to hydrochloric acid
se pure.

ng solution of hydrochloric acid evolves fumes on exposure to air. When
it gives off hydrochloric acid gas, until the temperature slightly exceeds 100° C.,
ere distils over a diluted solution of the acid, having a specific gravity of 1·1,
sisting of 1 atom of hydrochloric acid, HCl, dissolved in 8 atoms of water, H^2O.

From the experiments of Roscoe, however (Chem.
that the composition of aqueous hydrochloric acid (
constant boiling point, varies with the pressure, and
sure a corresponding aqueous acid, which undergoes
distilled under this pressure, and therefore has a con
column P shows the pressure in metres of mercury u
acid must be distilled to attain the composition given

TABLE A.—*Percentage of* HCl *in aqueous Hydrochlo*
Pressures.

P	Percentage of HCl.	P	Percentage of HCl.	P
0·05	23·2	0·7	20·4	1·3
0·1	22·9	0·76	20·14	1·4
0·2	22·3	0·8	20·2	1·5
0·3	21·8	0·9	19·9	1·6
0·4	21·4	1·0	19·7	1·7
0·5	21·1	1·1	19·5	1·8
0·6	20·7	1·2	19·4	1·9

The acid which boils constantly under the pressu
per cent. HCl, is the hydrate above mentioned, HCl.8
percentage of HCl in the aqueous acid of constant b
crease of pressure.

When aqueous hydrochloric acid is vaporised by pa
it at a *given temperature*, a point is likewise reached
occurs. In Table B the first column gives the temper
of HCl contained in the acid, unalterable at the corre

TABLE B.—*Percentage of* HCl *in Aqueous Hydrochlo*
at different Temperatu

T°	Percentage of HCl.	T°	Percentage of HCl.	T°
0° C.	25·0	30° C.	24·1	60° C.
5	24·9	35	23·9	65
10	24·7	40	23·8	70
15	24·6	45	23·6	75
20	24·4	50	23·4	80
25	24·3	55	23·2	85

The specific gravity of aqueous hydrochloric acid, of
has been determined by Ure and by E. Davy. The
and D; it will be observed that the specific gravit
rather lower for each percentage of HCl than those of

TABLE C.—*Percentage of* HCl *in Aqueous Hydroc*
according to E. Davy

Sp. Gr.	HCl.	Sp. Gr.	HCl.	Sp. Gr.
1·21	42·43	1·16	32·32	1·11
1·20	40·80	1·15	30·30	1·10
1·19	38·38	1·14	28·28	1·09
1·18	36·36	1·13	26·26	1·08
1·17	34·34	1·12	24·24	1·07

ABLE D.—*Composition of Aqueous Hydrochloric Acid according to* Ure.

c y.	Chlorine. per cent.	HCl. per cent.	Acid of sp. gr. 1·2.	Specific Gravity.	Chlorine. per cent.	HCl. per cent.	Acid of sp. gr. 1·2.	Specific Gravity.	Chlorine. per cent.	HCl. per cent.
0	39·675	40·777	66	1·1328	26·186	26·913	32	1·0637	12·697	13·049
2	39·278	40·369	65	1·1308	25·789	26·505	31	1·0617	12·300	12·641
4	38·882	39·961	64	1·1287	25·392	26·098	30	1·0597	11·903	12·233
6	38·485	39·554	63	1·1267	24·996	25·690	29	1·0577	11·506	11·825
8	38·089	39·146	62	1·1247	24·599	25·282	28	1·0557	11·109	11·418
0	37·692	38·738	61	1·1226	24·202	24·874	27	1·0537	10·712	11·010
3	37·296	38·330	60	1·1206	23·805	24·466	26	1·0517	10·316	10·602
5	36·900	37·923	59	1·1185	23·408	24·058	25	1·0497	9·919	10·194
7	36·503	37·516	58	1·1164	23·012	23·050	24	1·0477	9·522	9·786
6	36·107	37·108	57	1·1143	22·615	23·242	23	1·0457	9·125	9·379
2	35·707	36·700	56	1·1123	22·218	22·834	22	1·0437	8·729	9·971
2	35·310	36·292	55	1·1102	21·822	22·426	21	1·0417	8·332	8·563
2	34·913	35·884	54	1·1082	21·425	22·019	20	1·0397	7·935	8·155
2	34·517	35·476	53	1·1061	21·028	21·611	19	1·0377	7·538	7·747
1	34·121	35·068	52	1·1041	20·632	21·203	18	1·0357	7·141	7·340
1	33·724	34·660	51	1·1020	20·235	20·796	17	1·0337	6·745	7·932
1	33·328	34·252	50	1·1000	19·837	20·388	16	1·0318	6·348	6·524
1	32·931	33·845	49	1·0980	19·440	19·980	15	1·0298	5·951	6·116
1	32·535	33·437	48	1·0960	19·044	19·572	14	1·0279	5·554	6·709
1	32·136	33·029	47	1·0939	18·647	19·165	13	1·0259	5·158	5·301
0	31·746	32·621	46	1·0919	18·250	18·757	12	1·0239	4·762	5·893
9	31·343	32·213	45	1·0899	17·854	18·359	11	1·0220	4·365	4·486
8	30·946	31·805	44	1·0879	17·457	17·941	10	1·0200	3·968	4·078
7	30·550	31·398	43	1·0859	17·060	17·534	9	1·0180	3·571	4·670
6	30·153	30·990	42	1·0838	16·664	17·126	8	1·0160	3·174	3·262
5	29·757	30·582	41	1·0818	16·267	16·718	7	1·0140	2·778	3·854
4	29·361	30·174	40	1·0798	15·870	16·310	6	1·0120	2·381	3·447
3	28·964	:29·767	39	1·0778	15·474	15·902	5	1·0100	1·984	2·039
2	28·567	29·359	38	1·0758	15·077	15·494	4	1·0080	1·588	2·631
1	28·171	28·951	37	1·0738	14·680	15·087	3	1·0060	1·191	1·224
0	27·772	28·544	36	1·0718	14·284	14·679	2	1·0040	0·795	1·816
9	27·376	28·136	35	1·0697	13·887	14·271	1	1·0020	0·397	1·408
9	26·979	27·728	34	1·0677	13·490	13·863				
9	26·583	27·321	33	1·0657	13·094	13·456				

us hydrochloric acid possesses powerful acid properties, reddens litmus, tastes sour, effervesces with carbonates, and dissolves many metals with evolution gen. It does not bleach vegetable colours or dissolve gold leaf. W. O.

RHYDRIC ETHERS. See CHLORIDES OF ALCOHOL-RADICLES (p. 897).

ORHYDRINS. (Berthelot, Ann. Ch. Phys. [3] xli. 296.—Berthelot Luca, *ibid.* xlviii. 304; lii. 433.)—These compounds, which are precisely s to the bromhydrins (p. 667), are the chlorhydric ethers of glycerin, and may ded as derived therefrom by the substitution of one or more atoms of chlorine quivalent quantity of peroxide of hydrogen. They are produced, either by on of hydrochloric acid or of the chlorides of phosphorus on glycerin; the ethod does not however yield very good products.

chlorhydrin, $C^3H^7ClO^2 = (C^3H^5)'''.(HO)^2.Cl$, is obtained by saturating eated glycerin with hydrochloric acid gas; then keeping the liquid at 100° C. for urs; saturating with carbonate of sodium; agitating with ether; distilling the left after evaporation of the ether; and again treating it with carbonate of nd ether. It is a neutral oil, having a fresh ethereal odour and a sweet taste, gent after-taste. Specific gravity 1·31. It remains perfectly fluid at −35° C.; 227°; burns with a white, green-edged flame, emitting hydrochloric acid. f lead saponifies it slowly. It does not immediately precipitate nitrate of It mixes with its own bulk of water. With 8 or 10 times its bulk of water, it very stable emulsion. It also mixes with ether.

orhydrin, $C^3H^6Cl^2O = (C^3H^5)'''.HO.Cl^2$, is obtained by heating a solution of in 10 or 12 times its weight of fuming hydrochloric acid, to 100° C. for three lays, purifying the product with carbonate of sodium and ether as above, and

evaporating, first over the water-bath, then in vacu
ethereal odour. Specific gravity 1·37. It boils at 178°
burns like the preceding; is easily decomposed by p
sium and glycerin; mixes with ether, but does not f

Trichlorhydrin; Trichloride of Glyceryl, C^3H
pentachloride of phosphorus on dichlorhydrin:

$$C^3H^6Cl^2O + PCl^5 = PCl^3O + H$$

It is a neutral liquid, much more stable than trib
155° C. (Berthelot and De Luca.)

Epichlorhydrin. Oxychloride of Glyceryl. C
chlorhydrin with hydrochloric acid gas, or with t
sembling dichlorhydrin. Distils between 120° and

Epidichlorhydrin. Dichloride of Glycerylene
quantity in the preparation of trichlorhydrin and b
secondary reaction, inasmuch as it differs from dic
chlorhydrin by HCl. It is isolated and purified by
Neutral liquid, volatile at about 120° C. Treated w
reproduces glycerin. (Berthelot and De Luca.)

Dibromochlorhydrin, $C^3H^5Br^2Cl$.—Produced
phosphorus on dibromhydrin. Neutral liquid, volat
oxide of silver at 100°, it slowly reproduces glyceri
of chlorotritylene, $C^3H^5ClBr^2$.

Bromodichlorhydrin, $C^3H^5BrCl^2$.—Produced
phosphorus on dichlorhydrin. Neutral liquid, volatil
dichloride of bromotritylene.

With moist oxide of silver at 100°, it slowly repro
however, a small quantity of carbonic anhydride is f
crystalline scales, which appear to be propionate of s

$$C^3H^5BrCl^2 + 3H^2O = \underset{\text{Glycerin.}}{C^3H^8O^3} +$$

and

$$C^3H^5BrCl^2 + 2H^2O = \underset{\text{Propionic acid.}}{C^3H^6O^2} +$$

For the Acetochlorhydrins, see p. 25; Benzoch

CHLORHYDROPHENIDE. Chloride of Phe

CHLORHYDROPROTEIC ACID. A name
xvii. 316), to the precipitate formed by hydrochloric
by Mulder to contain 3·7 per cent. of hydrochlor
nothing but albumin.

CHLORIDES. The term chloride is applied to
may be derived from one or more atoms of hydrochl
tion of a metal or other radicle (which may itself c
quantity of hydrogen. Those which are volatile c
1, 2, 3, &c. atoms of chlorine, according as the rad
sociated is mono-, di-, tri-atomic, &c.*, thus:

2 vol. chloride of ethyl, $C^2H^5.Cl$,
" " sulphuryl, $(SO^2)''.Cl^2$
" " boron, $\overset{'''}{B}.Cl^3$
" " silicium, $\overset{''''}{Si}Cl^4$

Chlorides may be conveniently divided into the
contains compounds derived from one or more atoms

a. **Metallic Chlorides.** Chlorine combines
chlorine-atoms in the resulting molecule varying fro

α. Chlorides with one atom of chlorine, formed on
hydrochloric acid, namely, Monochlorides, HCl,
metals which form monochlorides are the alkali-m
The monochlorides are all soluble in water excep
insoluble. Monochloride of gold is completely deco
monochlorides melt when heated; and those of the
at higher temperatures.

---

[*] If, however, the radicle contains chlorine, this statement m
portion of chlorine which is not thus included, and is remov
example, 2 vols. chloride of trichloracetyl, $C^2Cl^3O.Cl$ contain
is removable by water, the compound, treated with water, yie
acid ($C^2Cl^3O.Cl + H^2O = HCl + C^2Cl^3O.H.O$).

rides with two atoms of chlorine, formed on the type H^2Cl^2, namely, Di-
es, $M''Cl^2$, and Dimetallic Protochlorides, $(M^2)''Cl^2$.—The metals
m dichlorides are barium, strontium, calcium, cerium, lanthanum, didymium,
, thorinum, magnesium, zinc, cadmium, nickel, cobalt, iron, manganese,
, lead, copper, mercury, platinum, palladium, osmium, ruthenium, molyb-
nd vanadium. These chlorides are all soluble in water, except that of
The dichlorides of platinum, palladium, and vanadium are decomposed by
others melt when heated, and volatilise unchanged at higher temperatures.
dichlorides are electrolytic.

llic protochlorides are formed only by copper and mercury, two atoms of the
metal being joined together by one unit of affinity, so as to form a bivalent
. $(Hg-Hg)''Cl^2$. These chlorides are insoluble in water, and under certain
nces have a tendency to split up into metal and the dichloride: Cu^2Cl^2 =
Cl^2.

rides with three atoms of chlorine, formed on the type H^3Cl^3, namely, *Tri-*
es, $M'''Cl^3$.—The metals which form trichlorides are antimony, arsenic,
gold, molybdenum, thallium, vanadium, and probably indium. The trichlo-
gold and thallium are decomposed by heat; the rest volatilise unchanged.
lorides of antimony and bismuth are very fusible solids: trichloride of
is known only as a crystalline hydrate; the rest are liquids. The volatile
es are decomposed by water, yielding hydrochloric acid and an oxychloride.

rides with four atoms of chlorine, formed on the type H^4Cl^4, namely, *Tetra-*
es.—These are formed by tin, titanium, vanadium, zirconium, and all the
metals, except rhodium. The first three are volatile liquids, the rest are
he general behaviour of these chlorides shows that two of the chlorine-atoms
ed less forcibly than the other two. The tetrachlorides of tin, titanium, and
num-metals are soluble in water; those of zirconium and vanadium are
ed by water.

ride with five atoms chlorine.—Pentachloride of antimony, $SbCl^5$. Volatile
composed by water.

rides with six atoms of chlorine, formed on the type H^6Cl^6, namely, *Dimetallic*
ides, $(M^2)^{vi}.Cl^6$. In these chlorides, two atoms of a tetratomic metal are
as to form a sexvalent group: *e.g.* $(Fe-Fe)^{vi}.Cl^6$. The metals which form
aluminium, cerium (?), chromium, manganese, iron. The cerium and
e compounds are known only as hydrates; aluminic, chromic, and ferric
are fusible and volatile solids. They are all soluble in water.

tion of Metallic Chlorides.—Chlorides are generally prepared by one or other
llowing processes. *a.* By acting upon the metal with chlorine gas. This
frequently employed for the preparation of anhydrous chlorides. The penta-
f antimony and protochloride of copper are examples of chlorides sometimes
in this manner. The chlorides of gold and platinum are usually prepared by
on the metals with nascent chlorine, developed by the mutual action of
ric and nitric acids. Sometimes, on the other hand, the metal is in a nascent
when titanic chloride is formed by passing a current of chlorine over a heated
f charcoal and titanic anhydride. The chlorides of aluminium and chromium
btained by similar processes.

orine gas, by its action upon metallic oxides, drives out the oxygen, and
th the respective metals to form chlorides. This reaction sometimes takes
rdinary temperatures, as is the case with oxide of silver; sometimes only at
t, as is the case with the oxides of the alkali- and alkaline earth-metals. The
and carbonates of these last metals, when dissolved or suspended in hot
treated with excess of chlorine, are converted, chiefly into chlorides, partly
rates.

ny metallic chlorides are prepared by acting upon the metals with hydrochloric
inc, cadmium, iron, nickel, cobalt, and tin dissolve readily in hydrochloric
h liberation of hydrogen; copper only in the strong boiling acid; silver,
palladium, platinum, and gold, not at all. Sometimes the metal is substi-
t for hydrogen, but for some other metal. Stannous chloride, for instance, is
y made by distilling metallic tin with mercuric chloride, thus: $HgCl^2 + Sn$ =
Hg.

the oxide, hydrate, or carbonate of metal may be dissolved in hydrochloric
n this way the hydrated dichloride of copper and trichloride of iron are
nade:

$$CuO + 2HCl = H^2O + CuCl^2.$$
$$Fe^2H^6O^6 + 6HCl = 6H^2O + Fe^2Cl^6.$$

eroxide, the reaction is accompanied by an evolution of chlorine, thus:

$$PbO^2 + 4HCl = 2H^2O + PbCl^2 + Cl^2.$$

ε. Chloride of silver and mercurous chloride, wh
chloride of lead, which is but sparingly soluble, are
of the corresponding soluble salts with a soluble chl

$$\mathrm{NaCl + AgNO^3 = AgCl +}$$

Decompositions.—1. The action of heat upon chl
Most protochlorides volatilise at high temperatures, w
chlorides give off part of their chlorine when heated.
the action of heat alone are decomposed by ignition
and free chlorine: this is the case with the chlorides
protochlorides remain undecomposed, even in this ca
cepting those of the alkali-metals and earth-metals
hydrogen gas, with formation of hydrochloric acid:
obtained in fine cubical crystals. Chloride of silve
zinc or iron, under dilute sulphuric or hydrochlor
state by the *nascent hydrogen.*—4. Metallic chlori
heat alone, likewise resist the action of *charcoal* at a
is likewise present, decomposition takes place, the
chloric acid formed, together with an oxide of carbo

$$\mathrm{2AgCl + H^2O + C = Ag^2 +}$$

—5. Metallic chlorides are not decomposed by hea
decomposes several of them.—6. Those metallic ch
by heat alone, likewise resist decomposition when h
hydride, or *silicic anhydride;* but if water is pre
and a borate or silicate of the metal is produced.
however, decomposes certain metallic chlorides, a sul
of equal volumes of chlorine and sulphurous anhydr

$$\mathrm{2NaCl + 2SO^2 = Na^2SO^4 +}$$

—7. *Sulphuric, phosphoric, boric,* and *arsenic acids,*
sometimes at ordinary, sometimes at higher temper
heated with *peroxide of lead* or *manganese* and *sulph*

$$\mathrm{2NaCl + MnO^2 + 2H^2SO^4 = Na^2SO^4 +}$$

—9. Distilled with *sulphuric acid* and *chromate*
bluish-red distillate of chloro-chromic acid.—10. S
posed by *water*, forming hydrochloric acid and an o
2HCl + BiClO. The chlorides of antimony and st
a similar manner.—11. All soluble chlorides give
white precipitate of chloride of silver, easily solub
acid. With *mercurous nitrate*, they yield a whit
chloride, blackened by ammonia; and with *lead-s*
talline precipitate of chloride of lead, soluble in exc

Combinations.—Metallic chlorides unite with eac
the non-metallic elements, forming such compounds
2KCl.Hg''Cl^2, chloroplatinate of sodium, 2NaCl.P
KCl.ICl^3, &c. They also combine with oxides and
and sulphochlorides. Metallic chlorides likewise co
ammonia and organic bases; the chlorides of platin
pounds 2NH^3.PtCl^2, 4NH^3.PtCl^2, 2NH^3.PtCl^4, and
forms with phenylamine the compound 2C^{6}H^{7}N.Hg''C
&c. Many of these compounds may be regarded as
formed on the ammonium type: thus ammonio-prot
= chloride of platammonium (NH^{3}Pt)^2.Cl^2.

Many metallic chlorides are soluble in alcohol, eth

b. **Chlorides of Organo-metallic Radicles**
These compounds, which bear considerable resemb
rides, are produced, either by the direct union of
radicle, or by the action of hydrochloric acid on the
Some of them are volatile liquids; others crystalli
or 4 at. of chlorine associated with 1 molecule of t
which contain an even number of atoms of alcoho
chlorides, while those which contain an uneven n
form di- and tetrachlorides, thus:

Arsen-monomethyl	forms	AsMeCl
Arsen-dimethyl	,,	AsMe^{2}C
Stib-triethyl	,,	SbMe^{3}Cl
Stib-tetramethylium	,,	SbMe^{4}Cl

compounds may be regarded as derived from a molecule of tri- or penta- arsenic or antimony by the substitution of an alcohol-radicle for an equiva- ty of chlorine (pp. 339, 397, 411).

rides of Alcohol-Radicles. *Hydrochloric or Chlorhydric Ethers.*— pounds may be regarded as derived from hydrochloric acid in a similar the metallic chlorides, or from the corresponding alcohols by the substitution for an equivalent quantity of peroxide of hydrogen, *e.g.*:

hloride of ethyl,	$C^2H^5.Cl$	from	Ethylic alcohol,	$C^2H^5.HO$
hloride of ethylene,	$C^2H^4.Cl^2$	„	Glycol,	$C^2H^4.(HO)^2$
hloride of glyceryl,	$C^3H^5.Cl^3$	„	Glycerin,	$C^3H^5.(HO)^3$

onatomic alcoholic chlorides are obtained:

action of hydrochloric acid on the alcohols:

$$C^2H^5.H.O + HCl = H^2O + C^2H^5.Cl.$$

action of the chlorides of phosphorus, or of oxychloride of phosphorus, on s:

$$3(C^2H^5.H.O) + PCl^3 = H^3PO^3 + 3C^2H^5Cl.$$
$$3(C^2H^5.H.O) + PCl^3O = H^3PO^4 + 3C^2H^5Cl.$$

action of chlorine on the corresponding hydrides. This reaction has been nly in the case of hydride of benzyl (p. 573).

these monatomic chlorides are liquids more volatile than the corresponding one, viz. chloride of methyl, is gaseous at ordinary temperatures, and chloride solid. Treated with alcoholic potash, they yield chloride of potassium and :

$$C^2H^5Cl + KHO = KCl + C^2H^5.H.O$$

ecently prepared, they do not precipitate nitrate of silver immediately; but are heated with it in sealed tubes, a slow precipitation takes place. Sodium y temperatures decomposes them, with formation of chloride of sodium and -radicle.

$$\underset{\text{Chloride of octyl.}}{2C^8H^{17}Cl} + Na^2 = 2NaCl + \underset{\text{Octyl.}}{C^8H^{17}.C^8H^{17}}.$$

at be applied, the sodium assumes a violet tint and swells up considerably. then becomes hot; hydrogen is evolved; the violet colour disappears; and ass is ultimately obtained, consisting of chloride of sodium and an oil, which esponding hydrocarbon, C^nH^{2n}: thus, with chloride of octyl:

$$2(C^8H^{17}.Cl) + Na^2 = 2(C^8H^{16}Na.Cl) + HH$$
$$\underset{\text{Violet substance.}}{C^8H^{16}Na.Cl} = NaCl + \underset{\text{Octylene.}}{C^8H^{16}}.$$

violet substance is produced by the simultaneous action of chlorine and octylene. It quickly turns white in contact with the air, yielding soda and of sodium, and is quickly decomposed by water, alcohol, and other liquids oxygen (Bouis, N. Ann. Chim. Phys. xliv. 114). A similar violet substance by the action of potassium on chloride of phenyl.

diatomic alcoholic chlorides are produced: 1. By the direct union of chlorine corresponding diatomic hydrocarbons, *e.g.* chloride of ethylene, chloride of &c.—2. By the action of pentachloride of phosphorus on the corresponding *g.*:

$$\underset{\text{Glycol.}}{C^2H^4.H^2.O^2} + 2PCl^5 = \underset{\text{Chloride of ethylene.}}{C^2H^4Cl^2} + 2POCl^3 + 2HCl.$$

ries of these chlorides are known, containing the radicles C^nH^{2n}, homologous lene, and C^nH^{2n-6}, homologous with benzylene.

lorides $C^nH^{2n}Cl^2$, are liquids, for the most part volatile without decomposition. decomposed by chlorine, yielding substitution-products. Heated with al- otash, they yield chloride of potassium, and the chloride of an aldehyde-

$$C^2H^4Cl^2 + KHO = C^2H^3Cl + KCl + H^2O.$$

le of potassium simply converts them into sulphides of diatomic alcohol-

$$C^2H^4Cl^2 + K^2S = 2KCl + C^2H^4S.$$

ith ammonia in sealed tubes, they appear to yield the same products as the ding bromides, viz. diamines containing 1, 2, or 3 at. of the radicles C^nH^{2n}; eactions have not been so much examined as those of the bromides. (See -BASES, p. 196; also ETHYLENE-BASES.)

The chlorides $C^nH^{2n-8}Cl^2$, are also volatile liquid
alcoholic potash, they yield chloride of potassium
benzylene yields bitter-almond oil. (Wicke, Ann.

$$C^7H^6Cl^2 + KHO = KCl +$$

Ammonia heated with chloride of benzylene i
(Wicke). With alcoholic sulphide of potassium,
rides last mentioned, yielding diatomic sulphides.

γ. Of *triatomic alcoholic chlorides*, only one is
trichlorhydrin, $(C^3H^5)'''Cl^3$, which is produced by
phorus on dichlorhydrin, $(C^3H^5)'''\begin{matrix}HO\\Cl^2\end{matrix}$. (See CHLOR

4. **Chlorides of Aldehyde-Radicles.**—The
general form $C^nH^{2n-1}Cl$, isomeric with the monoch
e.g. chloride of vinyl, $C^2H^3.Cl$, with chlorethylene,
action of alcoholic potash on the chlorides of the dia
times also by that of oxychloride of carbon on the
aldehyde, C^3H^4O (Harnitzky, p. 107). It is pr
tained by treating the aldehydes with pentachlo
isomer of butylic aldehyde, yields when thus treat

These chlorides are volatile liquids, except chl
ordinary temperatures. Chlorine converts them in
radicles.

5. **Chlorides of Acid Radicles.**—These co
by the substitution of chlorine for peroxide of hyd

Chloride of acetyl,	$C^2H^3O.Cl$	from	
Chloride of sulphuryl,	$(SO^2)''.Cl^2$	„	
Chloride of phosphoryl,	$(PO)'''.Cl^3$	„	

α. Monatomic acid chlorides are mostly deriv
only inorganic compounds of this class are *hydroc*
NO.Cl, produced by the direct combination of chl
the decomposition of nitromuriatic acid; and *chlo*
the action of oxychloride of phosphorus on nitrate o
$+ 3NO^2Cl$, or by the action of chlorhydrosulphur
$= NO^2Cl + KHSO^4$. Free chlorine, ClCl, may
sponding to hypochlorous acid, Cl.HO.

The chlorides of monatomic organic acids are
rides of phosphorus, or of the oxychloride, on the

$$\underset{\text{Benzoic acid.}}{C^7H^5O.H.O} + PCl^3.Cl^2 = \underset{\text{Chloride benzoyl}}{C^7H^5O.}$$

or of trichloride or oxychloride of phosphorus on

$$\underset{\text{Benzoate of potassium.}}{3(C^7H^5O.K.O)} + PCl^3O = K^3P$$

sometimes also by the action of chlorine on the co

$$C^7H^5O.H + Cl^2 = C^7H^5O$$

They are mostly fuming volatile liquids (chlori
remarkable for the facility with which they are d
tives (alcohols, alkalis, alkaline salts, &c.), and
ammonias.

Water transforms them into hydrochloric acid a

$$\underset{\text{Chloride of acetyl.}}{C^2H^3O.Cl} + H^2O = HCl +$$

With alkalis, in like manner, they yield the alkali
and with alcohols, compound ethers:

$$\underset{\text{Chloride of acetyl.}}{C^2H^3O.Cl} + \underset{\text{Alcohol.}}{C^2H^5.H.O} = HCl$$

Distilled with the alkaline salts of monobasic acid

$$\underset{\text{Chloride of acetyl.}}{C^2H^3O.Cl} + \underset{\text{Acetate of potassium.}}{C^2H^3O.K.O} = KCl$$

$$\underset{\text{Chloride of acetyl.}}{C^2H^3O.Cl} + \underset{\text{Benzoate of potassium.}}{C^7H^5O.K.O} = KCl$$

onia, or carbonate of ammonium, they yield primary amides:

$$C^7H^5O.Cl + NH^3 = HCl + N.H^2.C^7H^5O.$$

Chloride of benzoyl. Benzamide

ompound ammonias they yield alkalamides:

$$C^7H^5O.Cl + N.H^2.C^6H^5 = HCl + N.H.C^6H^5.C^7H^5O.$$

Chloride of benzoyl. Phenylamine. Phenyl-benzamide.

nner, with primary amides they form secondary amides:

$$C^7H^5O.Cl + N.H^2.C^2H^3O = HCl + N.H.C^2H^3O.C^7H^5O.$$

Chloride of benzoyl. Acetamide. Aceto-benzamide.

mic acid chlorides, derived from a double molecule of hydrochloric acid, and
ing to dibasic acids. Such are:

hloride of carbonyl (phosgene)	$(CO)''.Cl^2$
hloride of sulphuryl	$(SO^2)''.Cl^2$
hloride of succinyl	$(C^4H^4O^2)''.Cl^2$

nes of the vapour of these chlorides contain 2 atoms of chlorine capable of
into a metallic chloride by the action of a mineral alkali.
e obtained by the action of pentachloride of phosphorus on dibasic acids or
, the reaction, as shown by Williamson, consisting of two stages, the first
n the formation of a chlorinated acid, the second in that of a chloride, *e.g.*
uric acid:

$$\left.\begin{matrix}(SO^2)''\\H^2\end{matrix}\right\}O^2 + PCl^3.Cl^2 = (SO^2)''\left\{\begin{matrix}HO\\Cl\end{matrix}\right. + HCl + POCl^3.$$

Chlor-hydro-sulphuric acid.

$$(SO^2)''\left\{\begin{matrix}HO\\Cl\end{matrix}\right. + PCl^3.Cl^2 = (SO^2)''.Cl^2 + HCl + POCl^3.$$

Chloride of sulphuryl.

of sulphuryl and chloride of carbonyl are also formed by the direct combi-
chlorine with the radicles, under the influence of light.
tomic acid chlorides are liquid at ordinary temperatures, with the exception
e, which is gaseous. Their reactions are similar to those of the monatomic

tomic Acid Chlorides, corresponding to tribasic acids, and containing in
es of vapour, 3 vol. chlorine capable of conversion into a metallic chloride
ion of an alkali. Such are:

chloride of phosphorus	PCl^3
oride of phosphoryl (oxychloride of phosphorus)	$PO.Cl^3$
oride of sulphophosphoryl	$PS.Cl^3$
oride of boron	$B.Cl^3$
oride of cyanogen (solid)	$(CN)^3.Cl^3$

orides of arsenic and antimony must also be regarded as acid chlorides. The
ompound, commonly called chloride of nitrogen, is perhaps also a trichlo-
; but, according to some authorities, it contains hydrogen.
chlorides are produced, for the most part, by the direct action of chlorine on
s. Chloride of phosphoryl is produced by the action of water, and of various
of water, on the pentachloride, $PCl^5 + H^2O = 2HCl + POCl^3$; and chloride
hosphoryl, in like manner by the action of sulphydric acid on the penta-
All these compounds are decomposed by water and its derivatives in the
er as the mono- and di-atomic chlorides, yielding acids, salts, and compound
st of them unite with monatomic metallic chlorides, forming double chlorides.
tomic Acid Chlorides, containing 4 at. chlorine in 2 vols. of vapour. Some
tomic metallic chlorides are of acid character, viz. $SnCl^4$ and $TiCl^4$; chloride
$SiCl^4$, is also tetratomic. The only organic compound of this class is tetra-
carbon, CCl^4 (p. 765). In these chlorides, two of the chlorine-atoms are re-
forcibly than the other two.
tomic Acid Chlorides.—Two only of these compounds are known, viz. PCl^5
They are both volatile, but the antimonic chloride suffers partial decom-
the same time. To each of these chlorides there is a corresponding tri-
nd their general relations indicate that two of the chlorine-atoms are
ss forcibly than the other three.
at. of water, they yield hydrochloric acid and an oxychloride, *e.g.*:

$$PCl^5 + H^2O = 2HCl + PCl^3O,$$

but an excess of water likewise decomposes the oxy
and phosphoric or antimonic acid. Similar reaction
case of pentachloride of phosphorus, by alcohols, th
a chloride of the alcohol-radicle, and either oxychl
of the radicle, according to the quantities present.

$$PCl^5 \quad + C^6H^5.H.O \quad = C^6H^5.$$

and $$PCl^3O \quad + 3(C^6H^5.H.O) = (C^6H$$

With acids, or with salts of alkali-metal (aceta
chloride of phosphorus yields oxychloride of pho
chloride of the acid radicle (pp. 898, 899), and in
metal is present in excess, the corresponding anhy

$$\underset{\text{Benzoate of sodium.}}{C^7H^5O.Na.O} + PCl^5 \; = \; PCl^3.O \; +$$

and $$\underset{\text{Benzoate of sodium.}}{C^7H^5O.Na.O} + \underset{\text{Chloride of benzoyl}}{C^7H^5O.Cl} = NaCl$$

CHLORINDATMITE. A product of the ac

CHLORINDIN. See INDIN.

CHLORINE. *Symbol* Cl. *Atomic weight* 35·5.
as unity.) *Atomic volume* 1.

Chlorine is a substance very widely distributed
form of chloride of sodium, which constitutes rock-
sea-salt when dissolved in masses of water. The
sium, calcium, and magnesium. The chlorides of
respectively, form the partial or sole constituents o
free hydrochloric acid has been met with in th
Chlorine was discovered by Scheele in 1774. Its
blished by Davy in 1810.

1. Chlorine is usually prepared by the action of
manganese, at a gentle heat:

$$4HCl + Mn^2O^2 = 2H^2O +$$

The liberated chlorine may be washed by transmi
water, and dried with oil of vitrol in the usual ma
ward displacement. It cannot be collected over
action on the metal. It cannot readily be collected
therein; but the difficulty may be obviated by evo
the delivery tube to the summit of the receiver, or
perceptibly warm, or by saturating it with commo
peroxide of manganese may be replaced by acid chro
with questionable advantage, by several other oxid
oxide of lead, chlorate of potassium, hypochlorite
over, a mixture of common salt and oil of vitrol,
abundantly, may be, and frequently is, substituted
acid, thus:

$$2NaCl + 2H^2SO^4 + MnO^2 = Na^2SO^4 +$$

This is the method usually adopted on the larg
manufacture of bleaching powder, chlorate of potas
eliminating the whole of the chlorine from the ch
the decomposition of the peroxide by hydrochloric
as protochloride of manganese. The sulphuric aci
the effect of drying the chlorine. The materials are
spherical form, and constructed either entirely of
with a cast-iron steam-jacket, or of two hemisphe
the upper being of lead, the lower of iron. In t
by steam, in the latter over a very gentle open f
Manufactures and Mines, i. 666.)

Another method, which may be economically pra
sists in heating a mixture of common salt and nitr
excess of sulphuric acid. Hydrochloric and nitri
their mutual action generate chlorine, peroxide of

$$HCl + HNO^3 = Cl + N$$

The mixed vapours are made to pass into con
which absorbs the peroxide of nitrogen, forming a
wards used in the manufacture of sulphuric acid its

sses on and may be used for the preparation of chlorates or hypochlorites.
e of acid sulphate of sodium, left by the action of the sulphuric acid on the
nitre and salt, remains liquid, and may be run off into a furnace and heated
ditional quantity of salt, producing hydrochloric acid and neutral sulphate of
ich last may be used in the manufacture of soda. (*Traité de Chimie géné-
elouze et Frémy*, 3^{me} éd. i. 414.)

ine is also liberated by the simple action of a red heat upon certain chlorides,
se of palladium, platinum, and gold, thus: $PtCl^2 = Pt + Cl^2$. Pentachloride
y, $SbCl^5$, breaks up, when gently heated, into trichloride of antimony, $SbCl^3$,
lorine, Cl^2; and in like manner, the trichloride of gold, $AuCl^3$, breaks up
hloride of gold, AuCl, and free chlorine, Cl^2. Moreover, chlorine gas fre-
ults from the decomposition of its oxidised componnds.

s.—Chlorine has a yellowish-green colour, whence its name (χλωρός), and
irritating smell. It is irrespirable unless very much diluted. It is one of
t substances that are gaseous at common temperatures, being 35½ times
n hydrogen, and 2½ times heavier than atmospheric air. By a pressure of
pheres, at mean temperature 15·5° C., it is condensed into a yellow mobile
ng a specific gravity 1·33. It has resisted all attempts at solidification. At
mperatures, water dissolves about twice its volume of chlorine, forming a
ich has the colour, smell, and general chemical properties of the gas. At low
es, water dissolves a still greater proportion of chlorine, and at the tempera-
a definite hydrate of chlorine, $Cl.5H^2O$, crystallises out. If this hydrate be
med in a sealed tube, it will, at a temperature of 38° C., decompose into a
ater floating over a layer of liquid chlorine. This liquid chlorine may be
illed off, and condensed by means of a freezing mixture at the other extremity
e, which is usually bent for this purpose at an obtuse angle.

possesses very active chemical properties, and gives origin to many phe-
combination, substitution and indirect oxidation. It is moreover, non-
e, and does not unite directly with oxygen under any circumstances. At
mperatures, chlorine combines directly with all the *metals*, with many me-
ch as *hydrogen* and *phosphorus*, and with many compound bodies, such as
anhydride, SO^2, *olefiant gas*, C^2H^4, *benzene*, C^6H^6, and *carbonic oxide*, CO.
with phosphorus, and with finely divided arsenic, antimony, tin, or copper,
with the phenomena of combustion. At increased temperatures, chlorine
ith many other substances, such as *sulphur*, *selenium*, *boron*, and *silicon*.
been made to combine directly with *carbon*. When ordinary combustible
taining carbon and hydrogen, such as paper, wood, wax-taper, &c., are
immersed in a vessel of chlorine, the combustion continues chiefly at the
the hydrogen, which forms hydrochloric acid, while the carbon is deposited
black smoke. Previous ignition of the hydrocarbonised substance is not
essary to induce these phenomena. Paper dipped in oil of turpentine,
plunged in a vessel of the gas, takes fire spontaneously, yielding abundance
loric acid and carbon.

displaces *bromine*, *iodine*, and *fluorine*, from their combinations, by equiva-
tution. Free iodine strikes a deep blue colour with starch; and when
per dipped in iodide of potassium solution is brought into contact with
e iodine is liberated by the chlorine, and the characteristic blue iodide of
uced: KI + Cl = KCl + I. Chlorine also displaces *hydrogen* by equivalent
, one half of the chlorine taking the place of an equivalent quantity of
while the other half unites with the hydrogen eliminated:

$$\underset{\text{Salicin.}}{C^{13}H^{18}O^7} + Cl^2 = \underset{\text{Chloro salicin.}}{C^{13}H^{17}ClO^7} + HCl.$$

$$\underset{\text{Acetic acid.}}{C^2H^4O^2} + Cl^6 = \underset{\text{Trichloracetic acid.}}{C^2HCl^3O^2} + 3HCl.$$

by combining with hydrogen or a metal, acts indirectly as an oxidising
us, when chlorine-water is exposed to the action of sunlight, we have
= 2HCl + O. Again, when ferric hydrate, suspended in solution of hydrate
m, is treated with chlorine, we have produced ferric and hydrochloric acids,
with the alkali to form potassium salts:

$$H\ O + \underset{\text{Ferric hydrate.}}{Fe'''H^3O^3} + Cl^3 = H^2O.Fe^{vi}O^3,\ (\textit{i.e.}\ \underset{\text{Ferric acid.}}{H^2Fe^{vi}O^4}) + 3HCl.$$

destroys the colour of most organic pigments. This bleaching action is
ompanied by oxidation and substitution, thus:

$$\underset{\text{Indigo.}}{C^8H^5NO} + H^2O + Cl^4 = \underset{\text{Chlorisatin.}}{C^8H^4ClNO^2} + 3HCl.$$

Chlorine also destroys odours of various kind
either by abstracting hydrogen with or without
ing.

Antichloristic Theory.— Chlorine was original
namely, *Oxygenised muriatic acid*, or *Oxymuriati*
to be a compound of oxygen with the unknown
chlorine or oxygenised muriatic acid was suppose
with a larger quantity of oxygen. Moreover, as t
in contact with red-hot metals, evolves a large
of dry chlorine with 1 vol. of dry hydrogen for
acid gas, it was concluded that 1 vol. of chlorin
half volume of oxygen, which, in the formation
1 vol. of hydrogen; and that muriatic acid gas
numbers of atoms, of water, and a not yet isola
may be called *hypothetical anhydrous muriatic aci*
muriatic acid gas. Berzelius formerly arranged t
series as follows:

1 at. Murium=11·4 takes up of oxygen (=8)		and forms therewith		Antichlori
2 at. = 16	...	27·4 pts.	of	Hyp. anhyd.
3 „ = 24	...	35·4	„	Oxymuriatic
4 „ = 32	...	43·4	„	Euchlorine.
6 „ = 48	...	59·4	„	?
8 „ = 64	...	75·4	„	Hyperoxymu
10 „ = 80	...	91·4	„	?

It is easy to see that most of the phenomena ex
be rationally expressed in the language of thi
Muriatic acid gas is supposed to be a compou
muriatic acid =27·4 with 1 at. water = 9, making
chlorides are hypothetical anhydrous muriates of
be formed, with evolution of hydrogen, by contact
oxidation of the metal being produced by the wate
when a metal is immersed in oxymuriatic acid
away the third atom of oxygen of that gas, and
the remaining hypothetical anhydrous muriatic ac
hyperoxymuriate (chlorate), when oxymuriatic aci
solution of an alkali, is effected by 5 at. of oxy
atom of oxygen to a sixth atom of the same ac
hyperoxymuriatic acid [$6MuO^3 + 6KO = KO.$
cases in which chlorine is as an oxidising agent,
the element chlorine unites with hydrogen as a m
supposes that the third atom of oxygen in MuO^3,

On the same theory, phosgene gas (oxychloride
pound of hypothetical anhydrous muriatic acid wit
ride of phosphorus is a muriate of phosphorous aci
is $PO^5.5MuO^2$, both compounds being formed by
third atom of oxygen of MuO^3, whereby phospho
which unites with the resulting MuO^2.

Such was the theory of the chlorine-compoun
1809. In that year, however, Gay-Lussac and Th
on numerous experiments, that the chemical re
acid, or chlorine, might all be explained on the
substance, and this view was further carried ou
gave to this substance the name of CHLORINE. I
arguments by which this view was ultimately est
that chlorine has never been shown to contain ox
way of resolution into simpler forms of matter, an
of an element rests on the same foundation as tha
garded as elementary. (For further details, see G
Dictionary of Chemistry, 4th edition, p. 318.)

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* O = 8.

RINE, DETECTION AND ESTIMATION OF. 1. *Reactions.*—
in the free state is recognised by its suffocating odour, its yellow-green colour,
ing action which it exerts on litmus, indigo, and other vegetable colours, and
blue colour which it produces with a mixture of starch and iodide of potassium.
ous solution exhibits the same characters.
hloric acid and solutions of metallic chlorides, either neutral or slightly
d with nitric acid, give with *nitrate of silver*, an immediate white curdy pre-
f chloride of silver, insoluble in hot nitric acid, easily soluble in ammonia;
mercurous nitrate, a white curdy precipitate of mercurous chloride (calomel)
in nitric acid and in ammonia, and turned black by ammonia. Both these
are extremely delicate. Solutions of chloride of sodium of various degrees
n, give with nitrate of silver and mercurous nitrate, the reactions indicated
lowing table:

chlorine in:	Nitrate of Silver.	Mercurous Nitrate.
00 pts. water	Slight turbidity.	Slight precipitate.
00 " "	Immediate slight cloud.	Turbidity after a few minutes.
00 " "	Very slight turbidity.	Very slight turbidity after some minutes.
00 " "	Very faint opalescence.	Opalescence after some time.
00 " "	Scarcely perceptible opalescence.	Scarcely perceptible opalescence after some time.

olution of sal-ammoniac, the silver-solution behaves in a similar manner, and
erceptible cloud, even with 3,200,000 pts. of water; with the mercurous solu-
reaction ceases to be perceptible with 400,000 pts. of water to 1 pt. of chlorine.
gne, J. Chim. méd. viii. 518.)
ly salts which give with silver-solution a precipitate resembling the chloride,
nides, iodides, and cyanides. Either of these salts is easily detected in
of a chloride, viz. bromides and iodides by the colours of the bromine and
hen set free, and by their reaction with starch-paste; cyanides by the
of Prussian blue with ferroso-ferric salts; but the detection of small quan-
chlorine in presence of excess of either of the other salts, presents greater
. Bromide, iodide, and cyanide of silver are all insoluble in cold nitric acid,
or less soluble in ammonia. Iodine is, however, completely precipitated by
f palladium, which does not precipitate chlorine: consequently the chlorine
letected by adding nitrate of silver to the filtrate. The best mode of detect-
all quantity of a chloride in presence of excess of bromide, is to distil the
s with sulphuric acid and acid chromate of potassium, and pass the evolved
rs into ammonia: if chlorine is present, chlorochromic acid will be evolved,
iquid will be coloured yellow, from formation of chromate of ammonium; but
romine is present, it will remain colourless. Cyanide of silver dissolves
omposition when boiled with strong nitric acid, and may thereby be separated
chloride, which will remain undissolved.
greater number of metallic chlorides are soluble in water, the method of pre-
by nitrate of silver may be applied to them immediately. Cuprous chlo-
d many oxychlorides which are insoluble in water, dissolve in nitric acid,
hlorine contained in them may then be detected in the same manner. Oxy-
of chlorine, viz. the hypochlorites, chlorites, chlorates, and perchlo-
ve off their oxygen when heated, and are reduced to chlorides: the reduction,
in the case of perchlorates, may also be effected by sulphurous acid. The
es of phosphorus and other non-metallic elements, are decomposed by
elding hydrochloric acid, in which the chlorine may then be detected by nitrate
The chlorine in organic compounds is for the most part not imme-
recipitated by nitrate of silver, only indeed when it may be said to exist as
oric acid, namely, in combination with organic bases; from other organic
ds, as the chlorides of the alcohol- radicles, and the numerous class of com-
n which chlorine takes the place of hydrogen, it must first be separated,
ignition with lime, or by heating the compound with nitric acid in a sealed
225, 247).
antitative Estimation.—Chlorine is always estimated as chloride of
If not present as hydrochloric acid or a metallic chloride, it must be reduced
tate by one of the methods just indicated. The solution is then slightly
d with nitric acid in the cold (the application of heat to the acid solution
ive off part of the chlorine); nitrate of silver is added in excess; and the

liquid either briskly agitated with the precipitate
warm place, till the precipitate has completely sett
lected on a filter, which should be as small as possi
at 100° C. It must then be separated as complet
introduced into a porcelain crucible previously wei
side the crucible, the ashes added to the contents of
heated over a lamp till the chloride of silver is bro
after which it is left to cool and weighed. It conta
small portion of the chloride may be reduced by the
ignition, it is best, before weighing, to treat the co
nitric acid, in order to dissolve the reduced silve
porate to dryness, fuse, and weigh. The quantity
ner, will only be the equivalent of that which m
reduction. The chloride of silver may also be colle
in an oil-bath at about 150° C.

The quantity of chlorine in a soluble chloride m
cally, by precipitation with a standard silver-soluti
tains 30·42 milligrammes of silver, corresponding to

Volumetric Estimation of Chlorine in Hypochlor
the so-called "chlorides of lime, potash, and soda,
chlorites, chlorides, and hydrates of the respective
of hypochlorite which they contain, or, what comes
of chlorine which they evolve when treated with a

$$Ca''Cl^2O^2 + H^2SO^4 = Ca''SO^4$$

and this quantity may be conveniently estimated
anhydride which it will convert into arsenic anhyd
$Cl^4 + 2H^2O = As^2O^5 + 4HCl$. — *b.* By the quan
convert into ferric oxide.—*c.* By the quantity of
standard solution of iodide of potassium.

a. 14 grammes of pure arsenious anhydride,
caustic potash, and the solution is diluted to 1 litre
tains 0·014 grm. As^2O^3, and requires for its co
0·010 grm. chlorine ($As^2O^3 = 198 : Cl^4 = 142 : : 1$

Five grms. chloride of lime are triturated with w
duated cylinder and diluted to 100 c.c.; 50 c.c. o
in a beaker, diluted with water, saturated with h
by a drop of indigo-solution; and the solution of c
added from a burette, till the blue colour is nearly
is now to be added, and then the chlorine-solution
drop, the contents of the beaker being continually
appears. This marks the end of the operation: for
not take place till all the arsenious anhydride is
The percentage of available chlorine in the sample
that 45 c.c. of the arsenious solution have been empl
chlorine: consequently, the sample contains 9 pe
hypochlorite.

Another mode of proceeding is to act on a kn
solution of arsenious anhydride added in excess,
standard solution of iodine (p. 266). This, accor
method.

b. A weighed quantity of the sample is made to
sulphate added in excess, and the quantity of that
is estimated by a standard solution of permanganat
oxide converted into ferric oxide, corresponds to 1 a

$$2Fe''O + Cl^2 + H^2O = Fe^2$$

c. For the iodometric method, see ANALYSIS, VOL
see also *Ure's Dictionary of Arts, Manufactures an*

3. *Separation of Chlorine from other El*
tation by nitrate of silver serves to separate chlori
bromine and iodine.

To estimate chlorine in presence of *bromine*, the
gether by nitrate of silver, the precipitate dried, ig
just described (p. 904), and the bromine determine
From this the quantity of bromide of silver in the
tion Br : AgBr = 80 : 188; this deducted from t

antity of chloride of silver therein; and 24·74 per cent. of this last quantity nt of chlorine sought.

hod of estimating chlorine in presence of *iodine* is precisely similar.

lorine, bromine, and iodine occur together, the iodine is first precipitated f palladium (see Iodine), and in the filtrate the chlorine and bromine are as above. Or the three elements may be separated and estimated by hod (p. 678).

ic Weight of Chlorine.—The atomic weight of chlorine was determined **ius** (Ann. Ch. Phys. [2] xci. 102) in connection with those of silver and and the same method has been carried out, with very nearly accordant **Marignac** (J. pr. Chem. xxxi. 272; Ann. Ch. Pharm. xliv. 14), **Penny** a. 1839, p. 129), **Maumené** (Ann. Ch. Phys. [3] xviii. 41; Ann. Ch. Pharm. nd, lastly, by **Stas** (*Recherches sur les Rapports réciproques des Poids* Bruxelles, 1860). The series of operations is as follows:

ate of potassium, $KClO^3$, when heated to redness, gives off all its oxygen, oride of potassium, whence the atomic weight of chloride of potassium com· that of oxygen is known.

at. chloride of potassium throws down 1 at. of silver from its solutions, the ion of the quantity of chloride of silver precipitated by 1 at. chloride of gives the atomic weight of chloride of silver, AgCl.

known weight of silver be dissolved in nitric acid, and the quantity of potassium required to precipitate it be determined, the ratio between the ghts of silver and chloride of potassium becomes known; whence also the ght of chlorine may be found, by determining the weight of chloride of silver rom a given quantity of silver.

uantity of chloride of silver (c) produced from a given weight of silver (s) ther by igniting silver in chlorine gas, or by dissolving it in nitric acid and g by hydrochloric acid: hence, the atomic weight of chloride of silver (w) iously known, that of silver (x), is found by the proportion, $c : s = w : x$, f chlorine by difference; or, the atomic weight of silver being found from y of chloride of potassium required to precipitate it, that of chlorine is calm the composition of the chloride as just determined.

mination of the Amount of Oxygen in Chlorate of Potassium.—This may be either by heating the salt to redness, or else by reducing it with hydrod, evaporating to dryness, and igniting. In carrying out the former method, sary to arrange the apparatus in such a manner that any small particles of at may be carried away by the escaping gas may be collected and weighed. portions of oxygen and chloride of potassium in 100 pts. of the chlorate, omic weight of chloride of potassium thence determined, by the proportion $= 48 : x$, are as follows, according to the authorities above quoted:

	Berzelius.	Marignac.	Penny.	Maumené.	Stas.
. . . . .	39·150	39·161	39·177	39·209	39·154
. . . . .	60·850	60·839	60·823	60·791	60·846
	100·000	100·000	100·000	100·000	100·000
weight of KCl .	74·606	74·575	74·520	74·424	74·59

mination of the Atomic Weight of Chloride of Silver:

f chloride of potassium yielded, by precipitation with nitrate of silver:

	Berzelius.	Marignac.	Maumené.
loride of silver	192·4	192·35	192·75

f silver dissolved in nitric acid, require of KCl for precipitation:

Marignac.	Stas.
69·062	69·103

at. chloride of potassium precipitates 1 at. silver, forming 1 at. chloride of nce, according to Marignac —

$$100 : 192{\cdot}35 = 74{\cdot}575 : AgCl = 143{\cdot}44.$$

gniting 100 pts. of silver in chlorine gas, the following quantities of chloride re obtained:

	Berzelius.	Marignac. (1844.)	Marignac. (1845.)	Penny.	Maumené.	Stas.
. .	132·75	132·73	132·84	132·84	132·73	132·845

ing now Marignac's first number, 132·73 (which agrees with that of Maumené

and very nearly with that of Berzelius) with his d
of chloride of silver above quoted, viz. 143·44, we fi

$$132{\cdot}73 : 143{\cdot}44 = 100 : A$$

whence: $Cl = 143{\cdot}44 - 108{\cdot}0$
and: $K = 74{\cdot}575 - 35{\cdot}3$

If, again, we start from the same atomic weight
assume, according to Marignac's second determinatio
silver produce 132·84 pts. chloride; also that 100
69·062 KCl (Marignac), we arrive at the number
following table; those in the right are found in lik
of Stas:

Marignac.

$$\begin{array}{l|l}
Ag = \dfrac{100 \times 74{\cdot}575}{69{\cdot}062} = 107{\cdot}98 & Ag \\
Cl = \dfrac{107{\cdot}98 \times 32{\cdot}84}{100} = 35{\cdot}46 & Cl \\
K = 74{\cdot}575 - 35{\cdot}46 = 39{\cdot}12 & K
\end{array}$$

Dumas (Ann. Ch. Pharm. cxiii. 21), by ignit
that:

9·954 grm. silver gave 13·
19·976 „ „ 26·

whence, taking the atomic weight of silver at 108 (
of the nitrate by Marignac):

The first determination gives
The second „ „
Mea

This number 35·5, being also very near to the r
adopted.

CHLORINE, HYDRATE OF. $Cl.5H^2O$.—
vessel filled with chlorine, in quantity not exceeding
the vessel is exposed for some days to a freezing tem
hydrate is formed, sometimes in arborescent crystal
and rhombic octahedrons. It may be sublimed fro
When gently heated in an open vessel, it is resol
solution of chlorine. At 38° C. in a sealed tube, it
and free liquid chlorine, which separates as a disti
ammonia, ammoniacal salts, and alcohol in the s
(Faraday, *Quarterly Journal of Science*, xv. 71.)

CHLORINE, OXIDES, and **OXYGEN-A**
oxygen-acids, all of which may be regarded as oxid

Hypochlorous acid $HClO$
Chlorous acid $HClO^2$

They are obtained by the following processes:

1. Hypochlorous acid, $HClO$, is produced by oxi
manganic acid; and hypochlorite of potassium is
passing chlorine into a cold solution of potash:

$$KHO + Cl^2 = KClO +$$

2. Solution of hypochlorous acid, $HClO$, especia
converted spontaneously into chloric acid, $HClO^3$, t
oxygen. Moreover the solution of an alkaline h
time, breaks up into chlorate and chloride: $3KClO$

3. Chloric acid, $HClO^3$, when deoxidated by n
$HClO^2$; and conversely, chlorous acid, by its sponta
acid and other products.

4. Chloric acid, $HClO^3$, when oxidated at the p
yields perchloric acid, $HClO^4$. Moreover chlorate
heated, breaks up into perchlorate of potassium, chlo

Hypochlorites, chlorites, chlorates, and perchlorat
heated, are alike converted into chlorides by loss of

The anhydride of a monobasic oxygen-acid is form
the loss of one atom of water. The chlorine-acids sh
anhydrides:

Acids.		Anhydrides.	
$2HClO - H^2O$	=	Cl^2O	Hypochlorous
$2HClO^2 - H^2O$	=	Cl^2O^3	Chlorous
$2HClO^3 - H^2O$	=	Cl^2O^5	Chloric
$2HClO^4 - H^2O$	=	Cl^2O^7	Perchloric

two anhydrides are tolerably well known, the last two have not yet been We are, however, acquainted with the corresponding iodic and periodic es, I^2O^5 and I^2O^7, respectively. By the reabsorption of an atom of water, of each anhydride is reconverted into two atoms of the corresponding acid:

$$Cl^2O + H^2O = 2HClO$$
$$Cl^2O^3 + H^2O = 2HClO^2$$
$$(I^2O^5 \text{ or}) \ Cl^2O^5 + H^2O = 2HClO^3 \ (\text{or } 2HIO^3)$$
$$(I^2O^7 \text{ or}) \ Cl^2O^7 + H^2O = 2HClO^4 \ (\text{or } 2HIO^4)$$

ition to the above anhydrides, a complete series of chlorine-oxides should include three other terms, thus:

Cl^2	Chlorine	Cl^2O^4	Perchloric oxide
Cl^2O	Hypochlorous anhydride	Cl^2O^5	Chloric anhydride
Cl^2O^2	Chloric oxide ?	Cl^2O^6	Hyperchloric oxide ?
Cl^2O^3	Chlorous anhydride	Cl^2O^7	Perchloric anhydride

ran obtained from euchlorine (p. 913) a gas which decomposed into equal of chlorine and oxygen, a result considered by Berzelius to be conclusive of ence of chloric oxide. Hyperchloric oxide is not improbably identical with perchloro-chloric acid, Cl^6O^{17}, or $3Cl^2O^6$ (?) Perchloric oxide is a very wn substance, which, moreover, appears to be identical with Millon's chloro-cid, Cl^6O^{12}, or $3Cl^2O^4$ (?) Perchloric oxide is decomposed by water into and chloric acids:

$$Cl^2O^4 + H^2O = HClO^3 + HClO^3.$$

Hypochlorous Anhydride, Acid, and Salts.

CHLOROUS ANHYDRIDE. Cl^2O.—This gas, which was discovered by **Balard** (Ann. Ch. Phys. [2] lvii. 225), may be prepared: 1. By adding glacial phos-cid to a concentrated solution of hypochlorous acid standing over mercury. cial phosphoric acid abstracts water from the hypochlorous acid, and the anhydride thus produced collects in the upper part of the tube: $2HClO - Cl^2O$.

passing chlorine gas over mercuric oxide contained in a tube kept cool by

$$Hg''O + Cl^4 = Cl^2O + Hg''Cl^2.$$

rcuric oxide should be prepared by precipitation, and dried at a somewhat high ture, 300° C. Any excess of mercuric oxide remains combined with the re-mercuric chloride in the form of a brown crystalline oxychloride. The gas collected by downward displacement, or in the mercurial trough, but it cannot long over mercury, as it gradually acts upon the metal.

chlorous anhydride is a gas of a pale reddish-yellow colour, and a powerful omewhat resembling that of chlorine. Its specific gravity does not appear to en determined experimentally. By calculation, supposing the molecule to oc-wo volumes, it is $\frac{2 \times 35\cdot5 + 16}{2} = 43\cdot5$, referred to hydrogen, and 3·015 re-o air as unity. It is so readily decomposed into two volumes of chlorine and ume of oxygen, that it cannot be preserved unchanged, even for a few hours. ight elevation of temperature, or sometimes spontaneously, decomposition takes ith explosion. In sunlight the decomposition is very rapid, but usually tranquil. low temperature produced by a mixture of salt and ice, the gas is condensed leep orange-coloured liquid, heavier than water, and very explosive. Both the and liquid anhydride dissolve in water, undergoing decomposition and being ed into hypochlorous acid:

$$Cl^2O + H^2O = 2HClO.$$

neral reactions of the anhydride correspond with those of the acid, but are more

OCHLOROUS ACID. HClO.—This acid may be prepared:

om the anhydride, as just mentioned.

passing air saturated with hydrochloric acid through a solution of perman-

ganate of potassium, acidulated with sulphuric acid
distillate is a solution of hypochlorous acid formed b
chloric acid: $HCl + O = HClO$.

3. By the addition of almost any oxacid to a met

4. By passing chlorine gas into water, holding su
tallic oxides, hydrates, carbonates, sulphates, phosp
mercury, and, according to Williamson, carbonate of
advantageous. Either of these substances is to be ag
chlorine gas:

$$Ca''CO^3 + H^2O + Cl^4 = CO^2 + 2$$

The product of the action is to be distilled off, and
or two redistillations of the most volatile distillates.

Aqueous hypochlorous acid has a yellowish colour
istic sweet chloroïd smell. The strong acid decom
ice. The dilute acid is more stable, but is decomp
acid, water, chlorine, and oxygen. Hypochlorous aci
bleaching properties. Moreover, chloro-derivatives
thus:

$$\underset{\text{Benzene.}}{C^6H^6} + HClO = \underset{\text{Chloro-benzene.}}{C^6H^5Cl}$$

Hydrochloric acid decomposes hypochlorous acid, wi

$$HClO + HCl = H^2O$$

Hypochlorous acid is a very powerful oxidising ag
the elements, iodine, selenium, and arsenic, for inst
the same time liberating chlorine. The metals dif
nature of their respective reactions with hypochloro
the acid form oxides, as does iron, or oxychlorides, a
indeed, forms a chloride and liberates oxygen, thus:

$$Ag^2 + 2HClO = 2AgCl +$$

Many metallic oxides, those of manganese, cobalt
oxidised, with liberation of chlorine; but oxide of
silver, with liberation of oxygen:

$$Ag^2O + 2HClO = 2AgCl +$$

HYPOCHLORITES.—1. Pure hypochlorites are ma
acid with hydrates, such, for instance, as those of so
magnesium, zinc, copper, &c.—2. Hypochlorites
chlorine gas into solutions of hydrated or carbonate
of the earths. By this process, a chloride and a hy
duced. The reaction is believed to be as follows:

$$2Cl^2 + 2Ca''H^2O^2 = Ca''Cl^2 + Ca''$$

These mixed compounds constitute the bleaching a
the properties of which were known as early as the
long regarded as chlorides of the alkali- and earth-
lime, *chloride of soda*, &c., till Berzelius suggested
tures of metallic chlorides with alkaline chlorites (M
that their properties are best explained by regardin
and hypochlorites. The only objections to this view
chloride of calcium from bleaching powder, as we s
mixtures containing chloride of calcium, bleaching p
anomalies may possibly be due to the formation of
and hypochlorite of calcium in chemical combination

The pure hypochlorites, when acted upon by su
acid, liberate hypochlorous acid, thus:

$$Ca''Cl^2O^2 + H^2SO^4 = 2HClO$$

The mixed salts behave in the same manner, prov
excess; but otherwise chlorine, and not hypochlorou

$$Ca''Cl^2O^2 + Ca''Cl^2 + 2H^2SO^4 = 2H^2O$$

The sulphuric acid acts first upon the hypochlorite
then upon the chloride to liberate hydrochloric acid
acids cannot occur, owing to their mutual decomposi

ve already seen. Hydrochloric acid can liberate hypochlorous acid from the
iixed salts, thus: $NaClO + HCl = HClO + NaCl$. But any excess of hydro-
id immediately reacts upon the nascent hypochlorous acid to form water and
Solutions of the hypochlorites, either pure or commercial, are very unstable,
iore permanent in the presence of free alkali. They gradually give off oxygen
finally yield mixtures of chloride and chlorate. Their decomposition takes
y definitely at a boiling temperature, thus:

$$3Ca''Cl^2O^2 = Ca''(ClO^3)^2 + 2Ca''Cl^2.$$

elves they act as bleaching agents, probably by evolution of oxygen; but the
roduced by acidifying their solutions, and thereby liberating hypochlorous
much more rapid. With most metallic oxides and salts, the hypochlorites
does hypochlorous acid upon the oxides. They convert oxide of silver, for
into chloride of silver, with liberation of oxygen:

$$Ag^2O + 2NaClO + H^2O = 2AgCl + 2NaHO + O^2;$$

hate of manganese into hydrated peroxide of manganese, with liberation of
:

$$MnSO^4 + 2NaClO + H^2O = Na^2SO^4 + MnH^2O^3 + Cl^2.$$

aracters of the individual salts will be described in a distinct article (Hypo-
s). For the valuation of hypochlorites see p. 904.

Chlorous Anhydride, Acid, and Salts.

rous Anhydride. Cl^2O^3.—This gas, discovered by **Millon** (Ann. Ch.
xlvi. 298), results from the spontaneous decomposition of chlorous acid, which
what ill-defined and unstable substance:

$$2HClO^2 = H^2O + Cl^2O^3.$$

lso produced by the reaction of chloric acid with nitrous acid or anhydride:

$$2HNO^2 + 2HClO^3 = 2HNO^3 + H^2O + Cl^2O^3.$$

f preformed chloric acid and nitrous acid or anhydride, a mixture of chlorate
ium, nitric acid, and arsenious anhydride is usually employed. The nitric
st reduced by the arsenious anhydride to the state of nitrous acid, which is the
ygenant of the liberated chloric acid:

$$As^2O^3 + 2H^2O + 2KClO^3 = 2KH^2AsO^4 + Cl^2O^3.$$

tion is effected by the application of a very gentle heat. The arsenious anhy-
y be replaced by tartaric acid or other deoxidising agent. The gas must be
by displacement.

us anhydride is a yellowish green gas, permanent in a freezing mixture of ice
but liquefiable by extreme cold. Its specific gravity, calculated for a conden-
2 vols., is $\frac{71 + 48}{2} = 59{\cdot}5$ referred to hydrogen, and 4·123 referred to air.
ly elevated temperatures, 57° C. and upwards, it is decomposed, with explo-
chlorine and oxygen. It dissolves freely in water or in solutions of the alka-
earth-alkaline hydrates, gradually forming chlorous acid or chlorites.

rous Acid. $HClO^2$.—This acid may be prepared by condensing chlorous
e in water:

$$Cl^2O^3 + H^2O = 2HClO^2.$$

ing upon a chlorite with some diluted acid, such as sulphuric or phosphoric:

$$Pb(ClO^2)^2 + H^2SO^4 = 2HClO^2 + PbSO^4.$$

, or its concentrated solution, is a greenish yellow liquid of great tinctorial
nd having strong bleaching and oxidising properties. It does not decompose
es, but reacts slowly with caustic alkalis and earths to form chlorites.

rites. $MClO^2$.—The alkaline and earthy chlorites are formed as above de-
They also result from the action of perchloric oxide on bases (p. 912). They
he most part, soluble, crystallisable, colourless salts, possessed of bleaching
s. The insoluble chlorites of silver, lead, and other metals are produced by
ecomposition:

$$AgNO^3 + KClO^2 = KNO^3 + AgClO^2.$$

rites are decomposed even by carbonic acid.
e characters of the individual chlorites, see page 914.

Chloric Acid and

CHLORIC ACID. $HClO^3$. (Vauquelin, Ann. Ch
Phys. [2] xlv. 204, 270.)—1. The acid is liberated
stronger acid. It is found advantageous to use e
barium and sulphuric acid:

$$Ba''(ClO^3)^2 + H^2SO^4 = 2HCl$$

The solution of chloric acid is separated from the i
tration, and concentrated by evaporation in vacuo.-
spontaneous decomposition of solutions of hypochl
oxide of chlorine.

Chloric acid is a colourless syrupy liquid, having
warm, a pungent chloroïd smell. It is decompose
and frequently even with ignition. It is somewhat
At 40° C. it undergoes marked decomposition, and
verted into perchloric acid, water, chlorine, and ox
ing and bleaching agent. It is decomposed by hydr
acids, with liberation of chlorine.

CHLORATES. $MClO^3$ and $M''(ClO^3)^2$.—1. The
ting the acid with bases. Chlorate of barium is us
2. Zinc, and one or two other metals, dissolve
thus: $2HCl + Zn = Zn(ClO^3)^2 + H^2$; but a pa
more complex decomposition.
3. Alkaline chlorates are produced by boiling
what comes to the same thing, by passing chlorine
and boiling the resulting liquid: $3KClO = K$
separated from the chloride by crystallisation.

The chlorates are chiefly interesting as sources of
and most chlorates are decomposed by heat into ch
$KCl + O^3$; but the chlorates of the earth-metals
oxide: $Mg''(ClO^3)^2 = MgO + Cl^2 + O^5$. Prior to the
of potassium, a portion of perchlorate is produced.
oxidising agents. Mixtures of chlorate with comb
sulphide of antimony, and sugar, explode violent
percussion. Strong sulphuric acid liberates perchl
by its action on mixtures of chlorate with comb
combustion. Nitric acid reacts with chlorate of pot
perchlorate of potassium, and free chlorine and oxy
duces euchlorine, which is a gaseous mixture of
mixture of chlorate of potassium and hydrochlor
mineral and organic compounds. All the chlorates
not precipitate the salts of the heavy metals. C
portant member of the class, is one of the least sol
the chlorites, the chlorates do not bleach until afte
description of the individual salts, see pp. 885—8

Perchloric Acid an

PERCHLORIC ACID. $HClO^4$.—This acid was di
(Gilb. Ann. lii. 197), afterwards more particularly
Phys. [2] xlv. 270; xlvi. 294, 323), and quite rece
it in definite form. It is produced: 1. By the el
and chlorine are evolved in small quantities at the
negative pole; but the greater part of the oxygen
the chloric into perchloric acid (Stadion).—2.
(p. 910).—3. By the action of sulphuric acid upo
CHLORIC OXIDE, p. 912).—4. By the action of ce
Thus, fluosilicic may be added to perchlorate of p
fluosilicate of potassium filtered off from the solut
instead of fluosilicic acid may be employed, and
off from the sulphate of potassium. (Serullas.)

Aqueous perchloric acid obtained by either of t
by boiling till it attains a temperature of 203° C.,
in the form of an oily liquid containing 70·3 per

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[*] These results, not published when this article was written,

with twice its volume of strong sulphuric acid, it gives up its water to the
d perchloric acid passes over nearly pure in the form of a yellowish strongly
iquid. On continuing the distillation, the oily acid above-mentioned begins
ver; but as soon as it comes in contact with the more volatile portion of the
, the two unite into a crystalline mass consisting of a hydrate, $HClO^4.H^2O$.
ese products are, however, contaminated with sulphuric acid mechanically
ver. To obtain the volatile liquid in a pure state, the crystals must be redis-
se. They then split up into pure perchloric acid, $HClO^4$, which is obtained
st produce of the distillation, and the oily acid, which contains a larger pro-
f water, and passes over afterwards. (Roscoe.)
erchloric acid, $HClO^4$, is a colourless very volatile liquid, having a specific
f 1·782 at 15·5 C. Its vapour is likewise colourless and transparent, but on
n contact with the air, it absorbs water, and forms dense white fumes. Per-
cid in this state is one of the most powerful oxidising agents known; a single
ught in contact with charcoal, paper, wood, or other organic substance, imme-
causes an explosive combustion, which in violence does not fall far short
udden decomposition of chloride of nitrogen. The acid unites also very
ally with water, a violent hissing noise being produced. The greatest care
taken in working with this substance, as one drop falling on the skin produces
tion, and leaves a wound which does not heal for months. Like pure nitric
s acid cannot be distilled by itself without undergoing decomposition, a sin-
ck explosive body being produced when it is boiled. It likewise undergoes
ous decomposition at the ordinary temperature, the bulbs in which it was
ploding even when kept in the dark.
omposition of pure perchloric acid was determined by neutralising it with car-
f potassium, adding acetic acid to acid reaction, evaporating to dryness, throw-
perchlorate of potassium on a weighed filter, washing out the soluble acetate
olute alcohol, and determining the composition of the potassium salt thus pro-
In this manner results agreeing closely with the theory were obtained. Thus,
rm. of acid gave 1·6785 of potassium salt, calculation requiring 1·6876. Of
0·966 grm. heated with peroxide of iron lost 0·444 grm., and the residual KCl
0·744 grm. pure silver for complete precipitation. Now 0·744 Ag is equiva-
·513 KCl, and by calculation 0·966 $KClO^4$ should yield 0·519 KCl. (Roscoe.)
ydrate, $HClO^4.H^2O$ (containing 84·81 per cent. $HClO^4$), is obtained in the
te by adding water to the pure acid $HClO^4$. It is a white, solid, crystalline
e, which melts at 50° C., and undergoes decomposition when heated to 110°,
up into the pure acid and an aqueous oily acid. Its composition was deter-
y the method adopted in the case of the pure acid. The specific gravity of
d hydrate at 50° C. is 1·811. Although not so violent in its action on organic
s the pure acid, the fused hydrate when brought into contact with paper or
duces immediate combustion, and when dropped into water, combines therewith
hissing noise.
it is distilled, the temperature is found to rise gradually to 203° C., at which
remains constant, a heavy oily liquid then passing over, which in outward ap-
cannot be distinguished from sulphuric acid. This acid contains 72·1 per
HClO⁴, and does not therefore correspond to any definite hydrate, $HClO^4.2H^2O$
73·6 per cent. $HClO^4$, and $HClO^4.3H^2O$, requiring 65·05 per cent. $HClO^4$.
us perchloric acid be concentrated by boiling, water goes off, and the tempera-
s to 200° C., when the acid is likewise found to contain 72·1 per cent. of
Hence an aqueous acid loses water, and the crystallised hydrate loses per-
cid on boiling under the ordinary atmospheric pressure, until both arrive at a
en no further change takes place, and an acid containing 72·1 per cent.
asses off unchanged. (Roscoe.)
us perchloric acid reddens litmus strongly, but does not bleach. It dissolves
iron, with evolution of hydrogen, forming perchlorates. When dilute, it is
d by sulphydric and sulphurous acids, which reduce all other oxacids of

HLORATES.—These salts are produced: 1. By the reaction of perchloric acid
als, oxides, sulphides, or carbonates, or of perchlorate of barium with sulphates,

$$2HClO^4 + Ba''H^2O^2 = Ba''(ClO^4)^2 + 2H^2O$$
$$Ba''(ClO^4)^2 + Na^2SO^4 = 2NaClO^4 + Ba''SO^4.$$

e decomposition of chlorates. During the decomposition of chlorate of potas-
eat, and after a considerable evolution of oxygen has taken place, the previously
t is observed to assume a pasty condition, and if the heat be then discontinued,
ue will be found to consist principally of perchlorate and chloride of potassium,

which two salts may be separated from one another
perchlorate being much the less soluble:

$$2KClO^3 = KClO^4 + K$$

Or, the chlorate of potassium may be decomposed

$$3KClO^3 + 2HNO^3 = KClO^4 + 2KN$$

and the resulting nitrate and perchlorate of potassi
Perchlorate of potassium is sparingly soluble
in general are soluble, crystalline, deliquescent
violently than the chlorates, when thrown on ignite
heat than do the chlorates to effect their decomposit
phuric acid liberates perchloric acid from the perc
ture rises to 100° C.: other acids liberate perchloric
salts with the bases of the perchlorates. Hence, u
not assume a yellow colour when acted upon by su
the description of the individual salts, see PERCHL

Perchloric Oxide and

PERCHLORIC OXIDE. Cl^2O^4.—This very explos
by Count Stadion (*loc. cit.*), may be prepared by
upon chlorate of potassium, whereby perchlorate o
sium, water, and perchloric oxide are produced:

$$3KClO^3 + 2H^2SO^4 = KClO^4 + 2KH$$

The chlorate should be purified by recrystallisat
adequate temperature, and then finely pulverised.
by little to sulphuric acid, made cool by a mixture
is produced. This is to be set aside for some time, a
bath, to be very gently heated in a retort. The ev
be collected by downward displacement. Calvert
mixed with carbonic acid, may be readily obtained
of potassium with crystallised oxalic acid to a tem
Perchloric oxide is a gas of a bright yellow colour
low temperature produced by a mixture of salt and
highly explosive liquid. Faraday succeeded in sol
cold produced by the evaporation of solid carbon
gas undergoes spontaneous decomposition into chl
sition is frequently, and, when induced by elevatio
attended by a violent explosion. The contact o
determines an explosion. Liquid perchloric oxid
ture of 0° C., to form a solid hydrate. At ordinary t
times its volume of the gas. The solution has a
action, bleaches powerfully, and is very unstable,
chlorous acid, and other products. Perchloric oxi
with formation of chlorate and chlorite:

$$2KHO + Cl^2O^4 = KClO^3 +$$

The molecule of perchloric oxide Cl^2O^4, like the m
binary or dyadic, and to halve itself in the act of
correlations of chlorite and chlorate would corresp
pochlorite, thus:

$$\text{Chloride } \left.\begin{matrix}H\\Cl\end{matrix}\right\} \quad \text{Hypochlorite } \left.\begin{matrix}H\\Cl\end{matrix}\right\}O. \quad \text{Chlori}$$

EUCHLORINE.—When chlorate of potassium is
bright yellow gas, called euchlorine, is liberated.
gen in the same proportions as hypochlorous anhyd
of composition, it is evidently a mixture, probab
The following equation is believed to express its f

$$4KClO^3 + 12HCl = 4KCl + 6H^2$$

This mixed gas has a sweet aromatic smell, and
passing it through a U-tube immersed in a mixtur
is separated in the liquid state from the free u
Millon, the liquid perchloric oxide obtained by c
liquid perchloric oxide obtained by means of sulph
in its somewhat greater stability, in its somewhat

nce that, although, like the normal compound, it is decomposed by alkalis
ate and chlorite, yet that, unlike the normal compound, it yields two equi-
the former for one of the latter salt. Hence Millon assigns to it the formula

$$Cl^4O^{13} + 6KHO = 3H^2O + 4KClO^3 + 2KClO^2,$$

differences may probably be due to differences in the purity of these two
Moreover, perchloric oxide is a very difficult subject to investigate, and the
ns of different experimentalists vary considerably from one another. (See
Handbook, ii. 304, 310.) W. O.

RINE, SULPHIDES OF. Two only of these compounds are known in the
viz. SCl and SCl^2. The former is analogous in composition to hypochlorous
, ClO, but exhibits no analogy whatever to that compound in its properties.
otful indeed whether the sulphur or the chlorine in these compounds is the
element; but they are usually regarded as *chlorides of sulphur*, and as such
ore fully considered. (See SULPHUR.)

observations apply to the compounds of chlorine and selenium.

RIODOFORM. *Dichlorinated Iodide of Methyl.* $CHCl^2I$. (Serullas,
Phys. [2] xxv. 314; xxxix. 225.—Mitscherlich, Pogg. Ann. xi. 164.—
rdat, Ann. Ch. Pharm. xxii. 2229.—Gm. vii. 337). This compound was dis-
y Serullas in 1824, but its composition was first correctly ascertained by
at. It is obtained by distilling iodoform with an equal weight of penta-
f phosphorus or mercuric chloride. The materials are intimately mixed, and
in a retort; the dark red distillate is decolorised with aqueous potash, then
with strong sulphuric acid, to free it from chloride of ethylene, afterwards
from the sulphuric acid by a tap-funnel, and purified by rectification.

doform is a transparent pale yellow liquid of specific gravity 1·96, having an
odour and saccharine taste, and becoming rose-coloured by exposure to the
emains fluid at the lowest temperatures, and is not decomposed by distillation.
sparingly soluble in water. Heated with strong aqueous potash, or with
potash, it yields formate, chloride, and iodide of potassium:

$$CHCl^2I + 2K^2O = CHKO^2 + 2KCl + KI.$$

with chlorine gas, it solidifies and yields trichloride of iodine.

RISAMIC ACID and **CHLORISAMIDE.** See ISAMIC ACID and ISA-

RISATIC ACID. See ISATIC ACID.

RISATYDE and **CHLORISATYDIC ACID.** See ISATYDE and ISA-

RISATIN. See ISATIN.

RISATOSULPHITES. See ISATOSULPHITES.

RITE. *Leuchtenbergite, Pennine.*—This name is applied to certain sili-
agnesia and alumina occurring in plutonic formations, and forming the cha-
ingredients of chlorite slate. It formerly included ripidolite and clinochlore,
ill applied to at least two minerals, differing in crystalline form, and some-
in chemical composition. Chlorite from Achmatowsk in the Ural is mono-
t the variety called *Pennine*, from Zermatt in the Valais, is hexagonal, generally
ix-sided tables with perpendicular edges, oP . ∞ P, or with bevelled edges,
here P denotes a six-sided pyramid with basal edges of 106° 50′ and pyramidal
32° 40′; also with other faces subordinate. Cleavage perfect, parallel to the
e crystals are sometimes imbedded singly, but more frequently grouped in
conical, or vermiform masses; also in minute scales, forming a deposit on other
Specific gravity 2·65 to 2·85. Hardness 2·0 to 2·5. Flexible in thin laminæ,
lastic. Colour various shades of green, from leek to blackish green. Small
re dichromatic, appearing red when viewed in a direction perpendicular to
cal axis. Lustre nacreous on the basal faces, vitreous to waxy on the
Transparent in thin laminæ, but generally translucent, and transparent on
only.

ieties of chlorite give off water when heated in a tube, and melt with difficulty
blowpipe to a black slag, sometimes magnetic. The mineral gives with fluxes
ions of iron, more rarely that of chromium, and is perfectly decomposible by
acid.

veral varieties of chlorite exhibit considerable diversity of composition; the
constituents are silica, alumina, magnesia, and water, the alumina, however,
en more or less replaced by ferric oxide and the magnesia by ferrous oxide.
wing are analyses: 1. Varrentrapp (Pogg. Ann. xlviii. 185).—2. Kobell

(J. pr. Chem. xvi. 470).—3. Brüel (Pogg. Ann. x
[3] ix. 396).—5, 6. Marignac (*ibid.* x. 430).—
13).—9. Schweizer (Pogg. Ann. l. 526).—10, 1

	SiO^2	Al^2O^3	$Mg''O$	Fe^2O^3
1. Achmatowsk .	30·38	16·96	33·97	—
2. Schwarzenstein .	32·68	14·57	33·11	—
3. Zillerthal . .	31·47	16·67	32·56	—
4. Pyrenees . .	32·1	18·5	36·7	—
5. Ala (Piedmont) .	30·01	19·11	33·15	4·81
6. Slatoust (Ural) .	30·27	19·85	33·13	4·42
7. " *white* .	30·80	17·27	37·07	1·37
8. *Leuchtenbergite* .	32·35	18·00	32·29	4·37
9. Zermatt (*Pennine*)	33·07	9·69	32·34	—
10. " "	33·36	13·24	34·21	5·93
11. Binnen "	33·95	13·46	33·71	6·12

These numbers may be approximately represen
$Al^2O^3.SiO^2$ + 4aq., which, if M denotes magnesiu
40·03 $Mg''O$, and 12·01 water. If alumina be rep

tion of $al'' = \frac{2}{3}Al$), the preceding formula may b
+ $\frac{1}{3}$aq. Besides the above localities, chlorite is
Vosges, and in various parts of the Eastern Unite
berg's Mineralchemie, p. 534; Handw. d. Chem. 2

Chlorite Earth is earthy chlorite in the old
to the distinction between chlorite and ripidolite,
minerals can scarcely be distinguished.

Chlorite Ferruginous. *Delessite.*—This mi
phyry of Oberstein and Zwickau. It is massive,
texture. Specific gravity 2·89. Hardness 2·5.
According to Delesse (Ann. Min. [4] xvi. 520) i
Al^2O^3, 8·17 Fe^2O^3, 15·12 $Fe''O$, 15·32 $Mg''O$, 0·4
which may be approximately represented by the g
+ 5aq. *Grengesite*, from Grengesberg in Dalecarl
27·01 SiO^2, 14·31 Al^2O^3, 2·18 Mn^2O^3, 25·63 FeO, 1
to be related to it. (Dana, ii. 296; *Rammelsber*

Chlorite Slate.—This name is applied to ch
including, however, those which are made up in li

Chlorite-Spar. See Chloritoïde.

CHLORITES. $MClO^2$ and $M''(ClO^2)^2$. (M
Ann. Ch. Pharm. xlvi. 281.)—Salts of chlorous
described, together with those of the acid, at p
been studied individually.

Chlorite of Barium. $Ba''(ClO^2)^2$.—Obta
baryta. By quickly evaporating the solution and
it may be obtained crystallised and free from ch
and decomposes at 235° C.

Chlorite of Lead, $Pb''(ClO^2)^2$, is prepared
acid nearly neutralised with lime or baryta, washi
thereby produced, and drying it. If the solution
of lead, the chlorite of lead is deposited in large
poses with a kind of explosion at 126° C. (Millo
cix. 317). It sets fire to flowers of sulphur when
rather large quantities of the salt are mixed with
negative metal, the mixture takes fire spontaneou
rite of lead introduced into sulphydric acid ga
turns white, from formation of sulphate of lead.
strong sulphuric acid and water, it evolves pure c
between 40° and 50° C., and yields 88·75 per cen

The mother-liquor filtered from the precipita
described mode of preparation, deposits on the si
luble yellowish crystals, which appear to be a com
(Schiel.)

Chlorite of Potassium. $KClO^2$.—Pota
acid, forms a deep red liquid, which, when conce
and leaves neutral chlorite of potassium in the fo
the contrary, chlorous acid be gradually added to
formation of the neutral salt takes a longer time,
colourless, the presence of free chlorous acid may
ing nitrate of lead into the peroxide. The saline

nse the chlorite of potassium will be completely resolved into chloride and te. The same decomposition takes place if it be heated to 160° C. (Millon.)

LORITE OF SILVER. $AgClO^2$.—Prepared by mixing a soluble chlorite containing t excess of base with nitrate of silver, and boiling the resulting precipitate of e and oxide of silver with water. The solution on cooling deposits the salt in crystalline scales. At 105° C. it decomposes with explosion. A mixture of it ulphur takes fire when triturated with a glass rod. In preparing the salt, an of chlorous acid must be avoided, as it would thereby be quickly resolved into te and chloride. (Millon.)

LORITE OF SODIUM. $NaClO^2$.—Deliquescent. Resembles the potassium-salt, not decomposed by a heat below 250° C. (Millon.)

LORITE OF STRONTIUM. $Sr''(ClO^2)^2$.—Deliquescent. Decomposes at 208° C. on.)

LORITOÏDE. *Chlorite Spar, Barytophyllite, Masonite.*—A coarsely foliated e silicate of alumina and iron found at Kosoibrod in the Ural, Bregratten in the and Gummuch-dagh in Asia Minor. Its specific gravity is 3·557; hardness 5·5 colour dark grey or greenish black; lustre faint and pearly. Gives off water heated in a tube, is infusible before the blowpipe, but becomes darker and mag- It dissolves completely in sulphuric acid.

ed to chloritoïde are: *Masonite*, from Rhode Island, which fuses with difficulty ark green enamel, and *Sismondine*, a dark greyish or blackish green mineral of c gravity 3·565 and hardness 5·5. Nearly infusible before the blowpipe, occur- the chlorite slate of St. Marcel.

lysis: *Chloritoïde.*—1. O. Erdmann (J. pr. Chem. vi. 86).—2. Bonsdorff . Jahresber. xviii. 233).—3. Hermann (J. pr. Chem. liii. 13).—4. Smith Min. [4] xviii. 300).—5. Kobell (J. pr. Chem. lviii. 40. *Masonite*, Whitney, Boston Soc. Nat. Hist. 1849, p. 100). *Sismondine*, Delesse (Ann. Ch. Phys. . 385).

	SiO^2	Al^2O^3	Fe^2O^3	$Fe''O$	$Mn''O$	$Mg''O$	Lime and alkali	H^2O	
itoïde									
Kosoibrod .	24·90	46·20	—	28·89	—	—	—	—	= 99·99
„ .	27·48	35·57	—	27·05	0·30	4·29	—	6·95	= 101·64
„ .	24·54	30·72	17·8	17·30	—	3·75	—	6·38	= 99·97
Gummuch-dagh	23·75	39·64	—	27·62	0·52	0·58	0·94	6·85	= 100·10
Bregratten .	26·19	38·30	6 00	21·11	—	3·30	—	5·50	= 100·40
asonite . .	28·27	32·16	—	33·72	—	0·13	—	5·00	= 99·28
smondine .	24·1	43·2	—	23·8	—	—	—	7·6	= 98·7

ong these analyses Nos. 3 and 5 of chioritoïde are the only ones in which the de- f oxidation of the iron appears to have been correctly determined; these agree imately with the formula $(2M''O.SiO^2).(M^2O^3.SiO^2) + 2aq.$, which, by substitu- i- for tri-equivalent metals, may be reduced to $M''O.2(\overset{\prime\prime\prime}{M}{}^2SiO^4.aq.)$. (*Rammels- Mineralchemie*, p. 864; Dana, ii. 298.)

LOROBENZALDIDE. Syn. with CHLORIDE OF BENZOYL. (See BENZOYL, RIDE OF, p. 566.)

LOROBENZAMIDE. See BENZAMIDE (p. 540).

LOROBENZENE. See BENZENE (p. 543).

LOROBENZIDE. Syn. with TRICHLOROBENZENE. (See BENZENE, p. 543).

LOROBENZIL. $C^{14}H^{10}ClO^2$. (Cahours, Ann. Ch. Phys. [3] xxiii. 350.) med by the action of pentachloride of phosphorus on benzilic acid: the product illed, and the portion which comes over above 250° C. washed, dried, and rec- It is a colourless, strongly-smelling oil, heavier than water; boils at about 270°. posure to moist air, or by the action of hot strong potash, it is quickly decom- into chloride and benzilate. With ammonia and phenylamine, it yields crystal- roducts.

F. T. C.

LOROBENZOIC ACID. See BENZOIC ACID.

LOROBENZOL. Syn. with CHLORIDE OF BENZYLENE. (See BENZYLENE, RIDE OF, p. 577.)

LOROBENZONITRILE. See BENZONITRILE (p. 563).

LOROBENZOPHENIDE. See BENZOIC ETHERS under BENZOIC ACID (p.

LOROBENZOYL, CHLORIDE OF. See BENZOYL, CHLORIDE OF (p. 56).

LOROCAFFEINE. $C^8H^9ClN^4O^2$.—A product obtained by the incomplete of chlorine on caffeine suspended in water (p. 708). When purified by three r crystallisations from water, it forms a light bulky mass. From alcohol it crys- s in needles. By the continued action of chlorine, it is resolved into chloride of cyanogen, methylamine, and amalic acid. (Ro ii. 96.)

CHLOROCAMPHENE. See CAMPHENE (p.

CHLOROCARBO-HYPOSULPHURIC A METHYLSULPHUROUS ACID. (See METHYL.)

CHLOROCARBONIC ACID. Syn. with O OF CARBONYL, or PHOSGENE (p. 774).

CHLOROCARBONIC ETHERS. Compoun ride of carbonyl on the alcohols. They may be r anhydride with the chlorides of the alcohol-radicles, type HHO.HCl, in which 2 at. of hydrogen are r third by an alcohol-radicle, R:

$$CO^2.RCl = \left.\begin{matrix}CO''\\R\end{matrix}\right\}$$

Their formation is represented by the equation:

$$CO''\left\{\begin{matrix}Cl\\Cl\end{matrix}\right. + \left.\begin{matrix}R\\H\end{matrix}\right\}O = HCl +$$

CHLOROCARBONATE OF METHYL. C^2H^3Cl Péligot, Ann. Ch. Phys. lviii. 52.)—Obtained by i flask filled with phosgene-gas:

$$CH^3.H.O + COCl^2 = HCl +$$

Colourless, very fluid oil, heavier and more volati odour; burns with a green flame. Gaseous ammo methyl (urethylane):

$$CO^2.CH^3Cl + NH^3 = \begin{matrix}N.H^2(CO\\CH^3\end{matrix}$$

CHLOROCARBONATE OF ETHYL. $C^3H^5ClO^2$. Phys. liv. 226.—Cloez, *ibid.* [3] xvii. 303.—Caho like the preceding; also by the mutual action of alc perchlorinated oxalate of methyl:

$$\underset{\substack{\text{Perchloro-}\\\text{formate of}\\\text{ethyl.}}}{C^3Cl^6O^2} + \underset{\text{Alcohol.}}{2C^2H^6O} = \underset{\substack{\text{Chlorocar-}\\\text{bonate of}\\\text{ethyl.}}}{C^3H^5ClO^2} +$$

$$\underset{\substack{\text{Perchlor-}\\\text{oxalate of}\\\text{methyl.}}}{C^4Cl^6O^4} + \underset{\text{Alcohol.}}{4C^2H^6O} = \underset{\substack{\text{Chlorocar-}\\\text{bonate of}\\\text{ethyl.}}}{2C^3H^5ClO^2} +$$

Colourless liquid, very mobile, having a suffocati Perfectly neutral to test-paper. Specific gravity 3·823. Boils at 94° C. Very inflammable. Burns by hot water, not by cold. Ammonia converts it r and carbamate of ethyl.

CHLOROCARBONATE OF AMYL, $C^6H^{11}ClO^2$, ap of phosgene gas on amylic alcohol, but is immedia converted into carbonate of amyl.

CHLOROCEROTIC ACID. See CEROTIC A

CHLOROCINNAMIC ACID. See CINNAM

CHLOROCINNOSE. HYDRIDE OF TETRACH

CHLOROCHLORIC ACID. Cl^6O^{13} (?) A Millon, (Ann. Ch. Phys. [3] vii. 298) by passing e of U-tubes cooled by freezing mixtures, the first to 0 chloric acid then condenses in the first, and chloro chlorine escapes at the end. Chlorochloric acid thus which boils at 32° C., and is converted into a yellow plosion at 70°. With caustic potash, it yields a chlorite of potassium, whence its composition is infe

$$Cl^6O^{13} + 3K^2O = 4KClO^3$$

Chlorochloric acid resembles perchloric oxide, ClO^2, proaches very nearly to it in composition ($6ClO^2 =$ nothing but perchloric oxide mixed with excess of c

CHLOROCODEINE. See CODEINE.

LOROCOMENIC ACID. See Comenic Acid.
LOROCUMENE. See Cumene.
LOROCUMINOL. See Cuminol.
LOROCYANAMIDE. }
LOROCYANILIDE. } See Cyanamide.
LORODRACONESIC ACID. Syn. with Chloranisic Acid. (See Anisic
)

LORODRACONYL. When chlorine is passed into oil of tarragon, a viscid
quid is found, called *chloride of draconyl*, containing 39·9 per cent. C and 3·5 H,
ring approximately to the formula $C^{10}H^{10}Cl^2O.Cl^2$; and this, when treated with
lic potash, yields another viscid oil, *chlorodraconyl*, containing 42·5 C and 3·4 H;
ly chloride of draconyl minus the elements of water. (Laurent, Rev. scient.
-Gerh. iii. 355.)

LORŒNANTHIC ACID. See Œnanthic Acid.

LOROFORM. *Dichlorinated chloride of methyl. Perchloride of formyl.* $CHCl^3$.
eiran, Ann. Ch. Phys. [2] xlviii. 131.—Soubeiran and Mialhé, Ann. Ch.
. lxxi. 225.—Liebig, *ibid.* i. 198; Dumas, Ann. Ch. Phys. [2] lvi. 115.—
ault, *ibid.* lxxi. 577.—Gm. vii. 342.)—Chloroform was discovered in 1831 by
iran, who called it *Ether bichlorique*, and independently in 1832 by Liebig, who
led it as a chloride of carbon: its true constitution was discovered by Dumas in
Hutman (J. Chim. méd. [3] iv. 476) states, on the authority of Porta's *Magia*
alis and Scott's *Letters on Demonology and Witchcraft*, that it was known in
r times, and used as a means of producing insensibility.

mation and Preparation.—1. Chloroform is produced, together with mono-
nated chloride of methyl, CH^2Cl^2, when a mixture of chlorine and gaseous chlo-
f methyl is exposed to the sun's rays. If the two gases be made to pass
uously into a vessel exposed to the sun and connected with a series of cooled
ers, the chloroform, being the least volatile of the products formed, condenses
nd if the current of chlorine be made rather strong, and the receivers not much
, the product consists almost wholly of chloroform.

By the action of alkalis on chloral:

$$\underset{\text{Chloral.}}{C^2HCl^3O} + KHO = \underset{\text{Chloroform.}}{CHCl^3} + \underset{\text{Formate of potassium.}}{CHKO^2}.$$

oral is distilled with excess of aqueous potash, soda or baryta, or with milk of
and the oily distillate is repeatedly agitated with water, separated from the water
pletely as possible by decantation, and distilled with 6 or 8 times its volume of
sulphuric acid in a perfectly dry apparatus. (Liebig.)

By the action of nascent hydrogen upon tetrachloride of carbon. (Geuther,
.)

By boiling trichloracetic acid with aqueous alkalis:

$$C^2HCl^3O^2 + K^2O = CHCl^3 + K^2CO^3.$$

By the action of hypochlorites, or of chlorine, in presence of alkalis on various
ic substances, viz.: *a.* On methylic, ethylic, and amylic alcohols, perhaps also on
cohols of the series $C^nH^{2n+2}O$. With common alcohol and hypochlorite of calcium
rincipal reaction appears to be:

$$^2H^6O + 5Ca''Cl^2O^2 = 2CHCl^3 + 2Ca''CO^3 + 2Ca''Cl^2 + Ca''H^2O^2 + 4H^2O;$$

ther products are likewise formed, and chlorine is set free.—*b.* On acetic acid
cetates; probably thus:

$$2C^2H^4O^2 + 3Ca''Cl^2O^2 = 2CHCl^3 + 2Ca''CO^3 + Ca''H^2O^2 + 2H^2O.$$

acetone.—*d.* On ethylsulphate or ethyltartrate of calcium.—*e.* On oil of tur-
ne and its isomers, the oils of lemon, bergamot, copaiba, &c.

e most economical method of preparing chloroform, and that which is always
ed on the manufacturing scale, is the distillation of alcohol with chloride of
The proportions used are about 6 pts. chloride of lime diffused through 30 pts.
, and 1 pt. alcohol of 33° Beaumé. The addition of slaked lime is also advan-
us, as it absorbs the chlorine, which would otherwise be set free, and thereby
ishes the quantity of secondary products. The following mode of preparation on
rge scale is given by Kessler (J. Pharm. [3] xiii. 162).

e apparatus consists of a large leaden cylinder, the sides of which are soldered
lead. Through the middle of the upper end passes a vertical rod, provided
e bottom with fans, and at the top with a curved handle, its lower extremity
ng on a pivot in the base of the cylinder. By this arrangement, the mixture

may be stirred up during the operation, and the h
the upper end of the cylinder there is also a wider
pleasure, and through which the materials are introd
inserted the delivery-tube by which the chloroform
densing apparatus. Opposite to this tube there pass
cylinder, a leaden tube, widened above like a fun
surface of the liquid. Into this funnel-tube, at some
serted a steam-pipe, serving to convey steam from a
tube; and above the point of insertion of the steam-
with a cock, which, when open, allows the steam to
and when shut directs it into the mixture in the cy
late the supply of vapour, and thereby regulates th
passes upwards through a worm-tube, enclosed in
Woulfe's apparatus, the last bottle but one of which
last with cotton saturated with alcohol. A close-sh
instead of the leaden cylinder. 40 kilogrammes (88
of lime are introduced into the cylinder by means o
adapted to its widest aperture, and provided, near its
zontal rollers pressing against each other, as in a
by their handles, serve to drive the chloride of lime
grammes (8·8 lbs.) of slaked lime are next introduced
hectolitre of water (22 gallons) at a temperature of
apparatus is now thoroughly luted, and the conten
fans. 4 kilogrammes of commercial alcohol are th
residues of former operations. If the distillation o
diately begin, steam is admitted from the boiler, and
is fairly set up. If the evolution of vapour becomes
through the funnel-tube. When the reaction is c
into the cylinder, and the contents, which are now
After 3 litres ($5\frac{1}{4}$ pints) have been distilled off, the re
form or alcohol. The contents of the cylinder are disch
the liquid portion drawn off, and used in the next op
two Woulfe's bottles likewise serves for the follow
may be repeated three or four times in a day. 1 kil
from 60 to 80 grammes of pure chloroform.

According to Simerling (Arch. Pharm. [2] liii. 2
form, in proportion to the alcohol used, is obtained
of lime, 1 pt. quicklime, 1 pt. alcohol, and 40 pts. wa
produced, amounts to nearly one-third of the alco
from 25 grm. alcohol).

The use of acetone for the preparation of chloro
the price of it is high, and the product does not exc
This proportion was obtained by first distilling 30 gr
of lime mixed with water, and rectifying the watery
lime. Chloroform obtained from wood-spirit has an
blackens when agitated with sulphuric acid. The l
form from 50 grm. wood-spirit.

For other methods see Ann. Ch. Pharm. xix. 210.-

Chloroform may be contaminated with alcohol, et
cording to Soubeiran, pure chloroform sinks in a mix
and water. According to Kessler, chloroform contai
on the application of this test. The presence of al
chloroform is mixed with water, whereas pure chl
J. Chim. méd. [3] iv. 279). Chloroform containing
when mixed with chromic acid or with sulphuric acid
pure chloroform produces no green colour (Cottell
roform prepared from wood-spirit is much less pure
The former is specifically lighter than the latter, has
and produces unpleasant sensations when inhaled.
6 per cent. of an empyreumatic oil, containing chlori
lighter than water, and boiling between 85° and 133°
separated by simple rectification, but is nearly, but n
with sulphuric acid. A similar oil, but in smaller quanti
paration of chloroform from alcohol; 20 kilogrammes
when rectified over the water-bath, only 40 grm. of r
heavier than water, has an odour different from that of
and its boiling point varies from 68° to 117° C. (Soub

gory (Proc. Roy. Soc. Edinb. 1850, p. 391), impure chloroform may be recog-
y the disagreeable odour which it leaves, after evaporation, on a cloth which
n moistened with it, and by the yellow or brown colour which it imparts to
of vitriol when agitated therewith. Pure chloroform placed upon oil of vitriol
s a contact-surface convex downwards; impure chloroform gives a plane con-
face. According to **Roussin** (J. Pharm. [3] xxxiv. 206), the purity of chlo-
may be tested by means of *dinitrosulphide of iron*, $Fe^6H^2S^5N^4O^4$ (a salt obtained
action of ferric chloride or sulphate on a mixture of sulphide of ammonium and
of potassium). Pure chloroform shaken up with this salt, remains colourless;
t contains alcohol, ether, or wood-spirit, it acquires a dark colour. To purify
rm, **Gregory** agitates it and leaves it in contact with oil of vitriol till the latter
nger coloured by it, then removes the chloroform, and places it in contact with
quantity of peroxide of manganese, to free it from sulphurous acid. According
ham (Pharm. J. Trans. x. 24), chloroform thus purified quickly decomposes,
fterwards found to contain hydrochloric acid and free chlorine. According to
ison (*ibid.* x. 253), chloroform keeps well after being once treated with oil of
but the continued action of that liquid (especially if contaminated with nitrous
xerts a decomposing action upon it.

erties.—Pure chloroform is a transparent and colourless oil of specific gravity
t 17° C. (**Regnault**); 1·52523 at 0° (**Pierre**). It boils at 61° (**Regnault**);
° with the barometer at 772·52 mm. (**Pierre**). In contact with platinum-
d with the barometer at 27″ 7‴, it boils in a dry vessel at 60·8°, but in contact
ater, at 57·3° (**Liebig**). Its vapour-density is 4·199, according to Dumas;
ccording to Regnault. By calculation (2 vol.) it is $\frac{12 + 1 + 3 \times 35\cdot5}{2} \times$
= 4·141. Chloroform remains liquid and transparent at −16° C. (**Pierre**),
y be solidified by the cold produced by its own evaporation; when it is thrown
double filter, the rapid evaporation at the edges causes the remaining portion
ify in white tufts (**Soubeiran** and **Mialhé**). It has a very pleasant, pene-
odour, a sweet, fiery taste, and its vapour, when inhaled, produces a sweet taste
palate. The inhalation of a small quantity of the vapour causes excitement
to that produced by nitrous oxide; but a larger quantity produces insensibility
in fact, a kind of coma: hence it is extensively used in surgical operations.*
ng to **Robin** (Compt. rend. xxx. 52) and **Augendre** (*ibid.* xxxi. 679), chlo-
preserves meat from putrefaction (200 times its weight, according to Augendre).
oform dissolves slightly in water, imparting its sweet taste to the liquid. It
n all proportions with alcohol, and is partially precipitated therefrom by water.
lves rapidly in ether. It is quite insoluble in sulphuric acid.

ssolves *phosphorus*, *sulphur*, *iodine*, and *iodoform*, also many *organic bases* and
lts. The solubility of several organic bases in chloroform has been determined
chael Pettenkofer (Jahresber. f. Chem. 1858, p. 363) and **A. Schlimpert**
859, p. 405), whose statements however differ widely, as the following table will

Quantities of Alkaloïds dissolved by 100 *pts. of Chloroform.*

	Pettenkofer.	Schlimpert.		Pettenkofer.	Schlimpert.
ne . . .	0·57	1·66	Veratrine . . .	58·49	11·6
etate . .	—	1·66	Atropine . . .	51·69	33·0
ine . . .	37·17	—	Strychnine . .	20·16	14·1
e . . .	57·47	15·0	nitrate . .	—	6·6
lphate . .	—	0	Caffeine . . .	—	11·1
drochlorate .	—	11·1	Brucine . . .	56·79	14·0
nine . .	4·31	2·5	Digitaline . . .	—	1·25
lphate . .	—	3·0	Aconitine . . .	—	22·0
ine (?) . .	—	25·3	Santonine . . .	—	23·0

mpositions.—1. Chloroform decomposes when exposed to air and light, with
on of chlorine, hydrochloric acid, and other products; but when kept under
it remains unaltered (**Marson**, Pharm. J. Trans. viii. 69).—2. At a red heat

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r the introduction of this valuable remedy we are indebted to Dr. Simpson; and although ether,
and many other liquids can produce insensibility to pain, chloroform is of all the most powerful
s the most manageable. Of course great care must be taken to insure its purity, for the oils
ccompany it are very deleterious; and in administering it, one person should do nothing but
e pulse and respiration of the patient and remove the chloroform if necessary. With due pre-
chloroform is very safe; and this precaution will prevent its being used in cases where its use
-indicated by the disease of the heart, or by marked tendency to apoplexy." (**Gregory**, *Hand-
Organic Chemistry*, 3rd ed. London, 1852, p. 178.)

its vapour appears to be resolved, partly into trichlor
partly into carbon, hydrochloric acid, and chlorine:

$$2CHCl^3 = C^2Cl^6 + H$$

and:

$$CHCl^3 = C + HCl$$

The liberation of chlorine in this manner is applied
in blood. A quantity of blood, not less than an ou
after its separation from the organism, into a flask co
shaped tube somewhat drawn out in the horizontal ar
with starch-paste and iodide of potassium, is inserted
drawn-out part is heated to redness; and the flask
vapour of chloroform thereby evolved is decomposed
and the liberated chlorine turns the paper blue. Thi
detecting 1 pt. of chloroform in 1,000,000 pts. of blo
170). According to Duroy (J. Pharm. [3] xx. 401),
the blood be taken from the animal immediately after
or immediately after death. Duroy considers it bet
through the blood; then pass the air, together with t
red-hot tube, and thence into a solution of nitrate of
be present, a precipitate of chloride of silver will be f

3. Chloroform cannot be set on fire in the air, not e
its vapour passed into the flame of a spirit-lamp, bu
chloroform and alcohol in equal measures, burns with
odour, producing hydrochloric acid (Soubeiran, Lie
to the flame of a candle (Liebig).—4. Chloroform re
dry *chlorine*, is resolved into HCl and C^2Cl^4 (Regnau
nitric acid evolves but a small quantity of nitrous f
kept under *sulphuric acid*, it gradually gives off vap
alcoholic solution of chloroform, mixed with *nitrate of*
ride of silver, even in the course of a month (Soubeir
in a closed tube, it is resolved into formate and chlo
composition is imperfect (Dumas):

$$CHCl^3 + 2K^2O = CHKO^2$$

Chloroform is not decomposed by boiling with aqu
(Liebig). Alcoholic potash boiled for a long time w
of potassium (Regnault). A mixture of chloroform,
sealed tube to 100° C. for a week, yields ethylene-gas
Ann. Ch. Phys. [3] liv. 87).—8. Chloroform vapour
lime, yields metallic chloride, carbonate, and charcoal
products are not accompanied by any gas; but at a
produced by the action of the charcoal on the alkaline c
—9. Chloroform may be distilled over *potassium* wit
sium heated in its vapour takes fire with explosion,
mixed with charcoal (Liebig). It is not decompose
with it to 200° C. in a sealed tube (Heintz). Ch
heating with cyanide of potassium, mercury, or silver,
(Bouchardat.)

A mixture of chloroform and ammonia-gas is decom
dull redness, yielding chloride and cyanide of ammoni

$$CHCl^3 + 5NH^3 = 3NH^4Cl +$$

If the temperature be raised too high, a brown sub
cyanogen. When a solution of ammonia in absolute a
to a temperature between 180° and 190° C., formate
as well as cyanide; in many instances also neither o
a brown mass, probably consisting for the most part of
Ann. xcviii. 263.)

Chloroform and *phenylamine* do not react at ordinar
volumes of the two are heated to 180°—190° C. in
phenylamine is formed, together with hydrochlorate o

$$CHCl^3 + 4(N.H^2.C^6H^5) = 2[(N.H^2.C^6H^5).HCl] +$$

(Hofmann, Proc. Roy. Soc. ix. 229.)

CHLOROFORMYL - HYPOSULPHURIC
METHYL-SULPHUROUS ACID. (See METHYL.)

CHLOROGENIC ACID. Syn. with CAFFETAN

OROGENIN. A substance which accompanies rubian precipitated from of madder by sub-acetate of lead, and forms a green powder when boiled with c or hydrochloric acid.

OROMELAL. A product of the action of chlorine on hydrate of myricyl Its analysis agrees approximately with the empirical formula $C^{30}H^{46-4}Cl^{1+4}O$. e, Ann. Ch. Pharm. lxxi. 144.)

OROMELANE. See CRONSTEDTITE.

OROMELANILINE. See MELANILINE.

OROMERCURATES. Compounds of mercuric chloride with basic metallic s, or with hydrochlorates of organic bases, *e.g. Chloromercurates of potassium*, $g''Cl^2$; $KCl.Hg''Cl^2$; $KCl.2Hg''Cl^2$; *Chloromercurate of morphine*, $C^{17}H^{19}NO^3$. $g''Cl^2$. They are obtained by mixing the aqueous or alcoholic solutions of the nt salts, and are for the most part crystallisable.

OROMESITATE OF METHYLENE. $C^8H^{10}Cl^2O^2$.—A crystalline e produced by the action of chlorine on methylic alcohol (*q. v.*)

OROMETHYLASE. $C^2H^2Cl^2$.—An oily liquid produced by the action of on acetate of trichloromethyl. It has the composition of *dichlorethylene*, nt, Ann. Ch. Phys. lxiii. 382.) (See ACETATE OF METHYL, p. 23.)

ORONAPHTHANE. See NAPHTHALENE.

ORONAPHTHALIC ACID. See NAPHTHALENE, CHLORINE-DERIVATIVES

ORONICEIC ACID. This name was given by St. Evre (Ann. Ch. Phys. 484), to an acid crystallising in microscopic four-sided needles, which he ob- y passing chlorine into a solution of benzoate of potassium, containing excess h. St. Evre assigned to this acid the formula $C^6H^4ClO^2$. But from the expe- of Pisani, made in Gerhardt's laboratory, it appears that this acid is nothing robenzoic acid, $C^7H^5ClO^2$. The acid prepared as above was found, after purifica- repeated crystallisation, to be identical in composition and properties with nzoic acid prepared by the action of pentachloride of phosphorus on salicylic on salycilate of methyl. E. Kopp likewise obtained nothing but chlorobenzoic passing chlorine into a solution of benzoic acid in caustic soda. Hence also, e inferred that St. Evre's *chloroniceamide* is identical with chlorobenzamide; *oronicene*, a volatile liquid obtained by distilling chloroniceic acid with baryta is the same as chlorobenzene, C^6H^5Cl; and that *chloronicine*, a base obtained action of sulphide of ammonium on chloronicine, is identical with chloro- mine. (Gerh. iii. 980.)

OROPAL. A hydrated ferric silicate, of which there are two varieties, the dal and the earthy. The former has a pistachio-green colour, is translucent on es, has a flat conchoïdal fracture; specific gravity 2·158; hardness 4·5. The s a light green colour, verging towards olive-green and brown, is sometimes com- netimes friable: the compact variety is very soft. The composition of this mineral onsiderably, as the following analyses will show: 1, 2, from Hungary (Bern- and Brandes, Schw. J. xxxv. 29); 3, 4, from the Meenser Steinberg, near en (Hiller, Jahresber. f. Chem. 1857, p. 671):

	SiO^2	Fe^2O^3	Al^2O^3	$Mg''O$	$Mn''O$	H^2O	
onchoïdal	46	33	1	2	—	18	= 100
arthy .	45	32	0·75	2	—	20	= 99·75
„ .	71·6	16·3	2·1	1·5	trace	8·3	= 99·8
onchoïdal	39·7	28·0	3·7	2·4	trace	26·1	= 99·9

haps a mixture in variable proportions of opal with a hydrated ferric silicate, $iO^2 + 3H^2O$, the conchoïdal variety analysed by Hiller, containing about 41 of the ferric silicate, the earthy variety, 70 per cent. (Jahresber. *loc. cit.*)

OROPALLADATES. Compounds of dichloride of palladium with the sic metallic chlorides, or with hydrochlorates. They are not much known.

OROPALLADITES. Compounds of protochloride of palladium with the sic metallic chlorides, or with hydrochlorates of organic bases; *e.g.* chloro- of potassium, $2KCl.Pd''Cl^2$; chloropalladite of strychnine, $2(C^{21}H^{22}N^2O^2.HCl)$.

OROPALMITIC ACID. See PALMITIC ACID.

OROPERCHLORIC ACID. Cl^6O^{17}?—A compound said to be produced sing chlorous anhydride to sunshine, the containing vessel being at the e immersed in water of 20° C. It is a reddish brown liquid which is de- by heat, but not explosively; forms extremely dense white fumes in con- moist air, and is decomposed by potash; yields 1 at. chlorite and 2 at. chlorate

of potassium: $Cl^6O^{17} + 3K^2O = 2KClO^2 + 4KClO^4$
vii. 298. It is perhaps hyperchloric oxide, Cl^6O^{18} =

CHLOROPHÆITE. A ferrous silicate, occurri
forms, in the Faroe Islands, also in the neighbourhood
a dark green colour, and subresinous lustre; specific
According to Forchhammer's analysis (Berz. Jahres
per cent. silica, 21·56 protoxide of iron, 3·44 magne
formula $2(\frac{7}{8}Fe''O.\frac{1}{8}Mg''O).3SiO^2 + 12H^2O$, which ma
cate of the form $(M^4H^8)Si^3O^{12} + 8H^2O$.

CHLOROPHÆNERITE. A hydrated ferrous
amygdaloïdal porphyry of Weissig in Saxony. It is
green streak; not very hard; of specific gravity 2·68
SiO^2, 12·3 $Fe''O$, and 5·7 H^2O, besides alumina, ma
(Jenzsch, Chem. Centr. 1856, 76.)

CHLOROPHANE. A variety of fluorspar, whi
tion.

CHLOROPHENESIC ACID. Syn. with Dic
PHENIC ACID.)

CHLOROPHENISIC ACID. Syn. with TRI

CHLOROPHENUSIC ACID. Syn. with PE

CHLOROPHENYL. This name was applied by
obtained by the action of boiling nitric acid on tric
in yellow scales insoluble in water, soluble in alcohol
brilliant scales. Analysis gave 37·8 per cent. C, 1·88

CHLOROPHOSPHIDE OF NITROGEN.

CHLOROPHYLL. (Berzelius, Ann. Ch. Pha
Verdeil, Compt. rend. xxiii. 689.—Schulze, *ibid.*
Pharm. lii. 421.)—The colouring matter of leaves an
It is extracted by digesting green leaves for several
filtered liquid to dryness, treating the residue with
solution a small quantity of milk of lime, which pre
while the alcohol retains a quantity of fat which wa
is separated from the lime by means of hydrochlor
the colouring matter, forming a green stratum at the
the ether, the chlorophyll is obtained in the pure sta

Chlorophyll thus prepared is an earthy powder, of
in the air, infusible, sustaining a heat of 200° C. w
posing at higher temperatures. It is insoluble in
easily soluble in alcohol, less in ether. Acids and al
a solution of alum precipitates it. Nascent hyd
(Mulder). Mulder represents chlorophyll by the
cannot be considered as established. According t
analogy to the colouring matter of blood, and like
quantity of iron. According to Morot (Jahresber.
is $C^{18}H^{20}N^2O^4$, and is always accompanied by a fat
is produced by the action of atmospheric oxygen on

$$2C^9H^{16}O^5 + O^2 = C^9H^{14}O + 4$$

and chlorophyll results from the simultaneous action
this fat, under the influence of light:

$$C^9H^{14}O + 2NH^3 + 10CO^2 = C$$

According to Schultze, chlorophyll forms the colou
malcules inhabiting ponds and ditches, such as p
(*Hydra viridis*, *Vortex viridis*, *Mesostomum virida*
polymorphus, *Ophrydium versatile*, *Bursaria vernali*

The name *Erythrophyll* has been given to the
autumn. It is soluble in water and alcohol; disso
and forms with lead-salts, a precipitate of a fine gre

CHLOROPHYLLITE. An altered form of co
necticut, and Unity, New Hampshire. It occurs
form as the original cordierite, of greyish or brownis
specific gravity 2·782. According to Rammelsberg
cent. SiO^2, 25·17 Al^2O^3, 10·99 Fe^2O^3, 10·91 $Mg''O$, tr
water (= 100·66), which numbers, if a small quanti
as protoxide, may be nearly represented by the form

$Si^{3}O^{8}$ + 3 aq., which is that of a hydrated cordierite. (*Rammelsberg's Mineral-*
. 833.)

OROPICRIN. $CCl^{3}NO^{2}$. (Stenhouse, Phil. Mag. [3] xxxiii. 53.—Ger-
nd Cahours, Compt. chim. 1849, pp. 34 and 170.)—This compound may be
as marsh-gas, CH^{4}, in which 1 at. H is replaced by NO^{2}, and 3 more by
It is produced: 1. By the distillation of picric acid, styphnic acid, or chry-
acid with chloride of lime and water: hence also when the bodies which
her of these three acids by treatment with nitric acid are first boiled with
id and then distilled with chloride of lime. To these belong: creosote, salicin,
umarin, the yellow resin of Botany Bay, liquid storax, benzoin, Peru-balsam,
n, gum assafœtida, ammoniacum, purree, aloes, extract of Campeachy wood,
, fustic, red sandal-wood, &c. Lastly, Dammara resin, and the chlorinated
med in the decomposition of usnic acid by chlorine, likewise yield chloropicrin,
eated with nitric acid and chloride of lime.—2. By treating picric acid with
water or aqua-regia, or a mixture of chlorate of potassium and hydrochloric acid.
pare it, aqueous picric acid is distilled with chloride of lime till, after about a
of an hour's boiling, no more heavy oil passes over with the water. Should
ue be still yellow, it must be redistilled with fresh chloride of lime. The oil
ted from the watery distillate, washed with water to which a little carbonate
esium has been added, dried by placing it over chloride of calcium, and

picrin is a transparent, colourless, strongly refracting oil, of specific gravity
oiling at 120° C. Its odour, in the dilute state, is peculiarly aromatic, but in
entrated state very sharp, and attacks the nose and eyes less persistently, but
violently, as volatile chloride of cyanogen and oil of mustard. It is neutral
able colours. It dissolves sparingly in water, very easily in alcohol and ether.
picrin sustains without alteration a heat of 150° C.; but when passed through
t tube, it is completely decomposed, yielding nitric oxide, chlorine, and tri-
of carbon. A small piece of potassium gently heated in the oil, causes strong
n: at ordinary temperatures, it forms in a few days chloride and nitrate of
n. Chloropicrin is not decomposed by aqueous potash, even after prolonged
but alcoholic potash gradually decomposes it, forming chloride and nitrate of
m. Aqueous ammonia exerts scarcely any action upon chloropicrin; but with
cal gas or alcoholic ammonia, it forms chloride and nitrate of ammonium. It
ted upon by sulphuric, nitric, or hydrochloric acid, even at the boiling heat.

OPICRIN. $CBr^{3}NO^{2}$. (Stenhouse, Phil. Mag. [4] viii. 36.)—Obtained, like
crin, by distilling picric acid with solution of hypobromite of calcium (lime-
ntaining bromine), and purified by washing with carbonate of sodium, agita-
n mercury, and digestion (not distillation) with chloride of calcium. It is a
s liquid heavier than water, having the acrid odour of chloropicrin. It is in-
n water, easily soluble in alcohol and ether. It may be heated to its boiling
bove 100° C.) without decomposition, but is then decomposed, with evolution
n-red vapours, even in an atmosphere of carbonic anhydride. At a higher
ture, it decomposes with slight explosion. The alcoholic solution is slowly
ted by nitrate of silver in the cold, immediately when heated.

OROPLATINATES. Compounds of tetrachloride of platinum with the
ic metallic chlorides, or with the hydrochlorates of organic bases: *e. g. Chloro-*
of ammonium, $2NH^{4}Cl.PtCl^{4}$; *Chloroplatinate of Strychnine*, $2(C^{21}H^{22}N^{2}O^{2}.$
l^{4}. (See PLATINUM.)

OROPLATINITES. Compounds of dichloride of platinum with more
tallic chlorides: *Chloroplatinite of potassium*, $2KCl.PtCl^{2}$. (See PLATINUM.)

ORORHODATES. Compounds of trichloride of rhodium with more basic
, *e. g. Chlororhodate of ammonium*, $4NH^{4}Cl.Rh^{2}Cl^{6}$.

ORORUBIN. See RUBIAN and MADDER.

OROSALICIN. See SALICIN.

OROSALIGENIN. See SALIGENIN.

OROSAMIDE. Syn. with HYDRIDE OF CHLORAZOSALICYL. (See SALICYL.)

OROSPINEL. A grass-green spinel from Slatoust in the Ural, of specific
·591—3·594. It contains, according to two analyses by H. Rose (Pogg.
20):

$Al^{2}O^{3}$	$Fe^{2}O^{3}$	$Mg''O$	$Cu''O$	$Ca''O$	
64·13	8·70	26·77	0·27	0·27	= 100·24
57·34	14·77	27·49	0·62	—	= 100·22

he formula $Mg''O.(Al^{2}O^{3}; Fe^{2}O^{3})$ or $Mg''(Al^{2}; Fe^{2})^{vi}O^{4}$. It is distinguished
lonite (p. 843) by the absence of ferrous oxide.

CHLOROSTRYCHNINE. See Strychnine.

CHLOROSTYRACIN. See Styracin.

CHLOROSUCCIC ACID. An acid obtained by the metamorphosis of perchlorinated succinate of ethyl. (See Succinic Ethers.)

CHLOROSUCCINIMIDE. See Succinimide.

CHLOROTEREBENE. See Terebene.

CHLOROSULPHURIC ACID. See Sulphuryl, Chloride of.

CHLOROVALERISIC ACID. Syn. with Trichlorovaleric Acid. (See Valeric Acid.)

CHLOROVALEROSIC ACID. Syn. with Tetrachlorovaleric Acid.

CHLOROXALOVINIC ACID. See Oxalic Ethers.

CHLOROXAMETHANE. Syn. with Pentachlorinated Oxamate of Ethyl. (See Oxamic Ethers.)

CHLOROXETHIDE. Syn. with Chloroxalovinic Anhydride. (See Oxalic Ethers.)

CHLOROXETHOSE. C^4Cl^6O. (Malaguti, Ann. Ch. Phys. [3] xvi. 19.—Obtained by the action of monosulphide of potassium on perchloric ether:

$$C^4Cl^{10}O + 2K^2S = 4KCl + S^2 + C^4Cl^6O.$$

To prepare it, 50 pts. of monosulphide of potassium are heated with 16 pts. of perchloric ether and 200 pts. of alcohol of 95 per cent. Chloride of potassium is then deposited; the liquid assumes a dark colour; and after a day, the deposit of chloride of potassium becomes covered with crystals of sulphur. On adding water to the liquid, chloroxethose separates in the form of an oil.

It is a colourless, limpid, oily liquid, having an agreeable odour like that of meadowsweet, and a saccharine taste. Specific gravity 1·654 at 20° C. Boils at 210° C. with slight decomposition. Insoluble in water, soluble in alcohol and ether. It is altered after some time by exposure to the air. It is not attacked by alkalis or by ordinary nitric acid; but nitric acid of specific gravity 1·5 attacks it strongly when heated. On exposing it to sunshine in an atmosphere of chlorine, crystals of perchloric ether make their appearance after a few days: $C^4Cl^6O + Cl^4 = C^4Cl^{10}O$. It likewise absorbs bromine in sunshine, producing perchlorobromic ether. Exposed to the action of chlorine under a layer of water, it yields hydrochloric and trichloracetic acids:

$$C^4Cl^6O + Cl^4 + 3H^2O = 4HCl + 2C^2HCl^3O^2.$$

CHLOROXYNAPHTHALIC ACID. See Oxynaphthalic Acid.

CHOCHOCA. A name applied by the natives of South America to dried potatoes prepared by exposing the peeled and boiled tubers to the alternate action of frost and sunshine.

CHODNEFFITE. Syn. with Cryolite.

CHOLACROL. $C^8H^{10}N^4O^{13} = C^8H^{10}(NO^2)^4O^5$ (?)—A product of the action of nitric acid upon bile. This action gives rise to both fixed and volatile products. The volatile substances formed are capric, caprylic, valeric, and butyric acid, together with an oily body which, when treated with strong caustic potash, is resolved into nitrocholic acid and cholacrol, which latter may be separated from the saline solution by decantation. It is an oily neutral body having a strong odour; dissolves sparingly in water, freely in alcohol and ether; when heated, it decomposes with slight explosion. (Redtenbacher, Ann. Ch. Pharm. lvii. 145.)

CHOLALIC ACID. $C^{24}H^{40}O^5$.—Syn. with cholic acid, the non-azotised acid obtained by the action of alkalis on taurocholic and glycocholic acids. (See Cholic Acid.)

CHOLEIC ACID. Syn. with Taurocholic Acid, the sulphuretted acid of bile.

CHOLESTERIC ACID. $C^8H^{10}O^5$.—This acid is produced, together with choloïdanic acid, oxalic acid, several volatile acids, and a resinous substance, by the action of nitric acid on cholesterin. Choloïdic and glycocholic acids treated with nitric acid yield the same products. To prepare it, cholesterin is treated with nitric acid in a retort, the distilled liquid being frequently poured back, whereby a resinous mass is produced, which slowly dissolves after prolonged boiling with excess of nitric acid. The liquid, when sufficiently concentrated in the retort, leaves an acid gummy residue, containing a large quantity of cholesteric acid, mixed with choloïdanic acid and a resinous substance; and this residue, on cooling, separates into two layers, the upper of which consists of crystalline choloïdanic acid, while the lower, which is viscid, consists chiefly of cholesteric acid containing a little oxalic acid. On saturat-

iquid with ammonia, precipitating by nitrate of silver, and boiling the preci-
h water, cholesterate of silver is deposited in crystalline crusts, which, when
ed by sulphuretted hydrogen, yield the acid.

eric acid is a yellowish gummy solid, resembling the gum of the cherry-tree.
quescent; very soluble in water and alcohol; has an acid, bitter, and astrin-
e, and is decomposed by distillation, giving off bitter vapours and leaving a
ble quantity of charcoal.

rmula of the *cholesterates* is $C^8H^8M^2O^5$. The alkaline and earthy salts are
nd uncrystallisable; the cholesterates of the heavy metals are insoluble.

ESTERIN. $C^{26}H^{44}O$.—This substance was first obtained by Conradi, in
n human gall-stones, of which it sometimes constitutes nearly the entire sub-
It has been found in human bile by Chevreul (Ann. Chim. xcv. 5; xcvi.
the blood by Lecanu (Ann. Ch. Phys. lxvii. 54), Boudet (*ibid.* lii. 336),
. Chim. méd. [2] iv. 161), and by Becquerel and Bodier (Gaz. méd. No.
n the brain (Couerbe, Ann. Ch. Phys. lvi. 281; Frémy, *ibid.* [3] ii. 486), in
gg (Lecanu, J. Pharm. xv. 1; Gobley, *ibid.* [3] xii. 12), and in certain
roducts of the animal economy, such as cerebral concretions, scirrhous matter
socolon, hydropic liquid of the abdomen, ovaries, testicles, &c. (Lassaigne
Phys. ix. 324; O. Henry, J. Chim. méd. i. 280; Caventou, J. Pharm. xi.
hmann, Lehrb. d. Physiol. Chem. 2^te Aufl. i. 286). The first exact analysis
terin was made by Chevreul, who assigned to it the formula above given.
morphoses have been studied by Marchand (J. pr. Chem. xvi. 37),
bacher (Ann. Ch. Pharm. lvii. 145), Meissner and Schwendler (*ibid.* lix.
J. pr. Chem. xxxix. 247), Zwenger (Ann .Ch. Pharm. lxvi. 5; lxix. 347),
(Pogg. Ann. lxxix. 524), and Berthelot (Ann. Ch. Phys. [3] lvi. 51).

terin is easily prepared by crystallising *biliary calculi* from boiling alcohol,
a little potash is added to dissolve any fatty acids that may be present. The
in is then deposited in colourless nacreous laminæ. To obtain cholesterin from
at substance is treated with ether, the ethereal extract boiled with alcoholic
nd the liquid left to cool. It then deposits cholesterin mixed with cerebrate
phate of potassium, from which the cholesterin may be dissolved out by ether.

terin is white, tasteless, inodorous, insoluble in water, sparingly soluble in
hol, but dissolves very easily in boiling alcohol, from which it separates on
n beautiful crystalline nacreous laminæ, soft to the touch, and melting at
It dissolves also in ether, wood-spirit, oil of turpentine, soap-water, and
ts. A solution of cholesterin in a mixture of 2 vols. alcohol and 1 vol. ether
by spontaneous evaporation laminated transparent crystals of hydrate of cho-
$C^{26}H^{44}O + H^2O$, which give off their water at 100° C.

terin resists the action of concentrated alkaline solutions even at the boil-
; but lime decomposes it at about 250° C., hydrogen being given off and
sterin being converted into an amorphous fatty body nearly insoluble in

terin is attacked by *chlorine* and *bromine*, yielding substitution-products; the
compound is $C^{26}H^{36}Cl^8O$. For the action of nitric acid upon cholesterin, see
RIC ACID.

terin sublimes without alteration at 200° C., but decomposes at a higher tempe-
ielding several oily products and a solid body. When distilled in a retort, it
carbonaceous residue and a neutral oily liquid insoluble in potash, from which
distillation with water separates a volatile oil having the agreeable odour of
s.

strong sulphuric acid is gradually added to a slightly heated mixture of cho
nd dilute sulphuric acid, the cholesterin becomes soft, acquires a deep red
d decomposes, giving off all its oxygen in the form of water, and is changed,
evolution of gas, into three isomeric hydrocarbons, which Zwenger designates
sterilin, *a*, *b*, and *c*; they are insoluble in water, and may be freed from sul-
id by washing with that liquid. These hydrocarbons are easily crystallisable,
cholesterin are remarkable for possessing high melting points. *a* has an
pect, melts at 240° C., and is nearly insoluble in alcohol, very sparingly so-
ther; *b* forms shining scales melting at 255°, moderately soluble in hot ether;
n the fused state it loses the power of crystallising; *c* is resinous without
ce of crystallisation, and melts at 127°, it is also soluble in hot ether.

oncentrated *phosphoric acid*, cholesterin forms two compounds, called choles-
a and β, isomeric with each other, but differing in physical properties. Cho-
α forms very brilliant rectangular prisms, melting at 68° C., and distilling
ithout alteration; easily soluble in alcohol and ether. The modification β
all silky needles sparingly soluble in ether, nearly insoluble in alcohol.

mposition of cholesterilin and cholesterone agrees nearly with the formula

$C^{26}H^{42}$; they are, therefore, either isomeric or polymeric. Their formation from cholesterin is represented by the equation:

$$C^{26}H^{44}O - H^{2}O = C^{26}H^{42}.$$

This decomposition shows that cholesterin partakes of the nature of an alcohol; it is, in fact, homologous with cinnamic alcohol, and its formula may be written $C^{26}H^{43}.H.O$. Heated with acetic, butyric, benzoic, and stearic acids, it forms compound ethers, with elimination of water; thus with stearic acid:

$$\underset{\text{Stearic acid.}}{\left.\begin{matrix}C^{18}H^{35}O\\H\end{matrix}\right\}O} + \underset{\text{Cholesterin.}}{\left.\begin{matrix}C^{26}H^{43}\\H\end{matrix}\right\}O} = \underset{\text{Stearate of cholesteryl.}}{\left.\begin{matrix}C^{18}H^{35}O\\C^{26}H^{43}\end{matrix}\right\}O} + H^{2}O.$$

These ethers are prepared in the same manner as the glycerides, and are purified by boiling the product with eight or ten times its volume of alcohol, which extracts the unaltered cholesterin, and crystallising from boiling ether.

Benzoate of Cholesteryl, $C^{33}H^{48}O^{2} = C^{7}H^{5}O.C^{26}H^{43}.O$, crystallises in small shining micaceous laminæ, which melt between 125° and 130° C., dissolve with moderate facility in ether, very sparingly in boiling alcohol. The *butyrate*, $C^{4}H^{7}O.C^{26}H^{43}.O$, is easily fusible, somewhat soluble in hot alcohol. The *stearate*, $C^{18}H^{35}O.C^{26}H^{43}.O$, crystallises in small shining needles, having a neutral reaction, sparingly soluble in cold ether, nearly insoluble in alcohol even at the boiling heat. The *acetate* has likewise been formed, but is difficult to purify, being more soluble in alcohol than the preceding compounds. (Berthelot.)

CHOLESTROPHANE. $C^{5}H^{6}N^{2}O^{3}$.—The name given by Rochleder to the final product of the action of chlorine on caffeine (*q. v.*), called also *nitrotheine* by Stenhouse, and regarded by Gerhardt as *dimethylparabanic acid*, $C^{3}(CH^{3})^{2}N^{2}O^{3}$. It is also obtained by the action of nitric acid upon caffeine. It is soluble in alcohol, and crystallises in iridescent scales, which sublime at 100° C. Boiled with potash it yields carbonate and oxalate of potassium, and gives off ammonia (according to Rochleder), or rather methylamine.

CHOLIC ACID. *Cholalic Acid.*[*] $C^{24}H^{40}O^{5}$.—This acid was discovered by Demarçay in 1838 (Ann. Ch. Phys. [2] lxvii. 177), further examined by Theyer and Schlosser (Ann. Ch. Pharm. xlviii. 77; l. 285), and finally by Strecker (*ibid.* lxv. 9; lxvii. 1; lxx. 161, 166). It is produced by the action of alkalis on the acids of bile, viz. glycocholic and taurocholic acids, the decomposition taking place in the manner represented by the equations:

$$\underset{\text{Glycocholic acid.}}{C^{26}H^{43}NO^{6}} + H^{2}O = \underset{\text{Cholic acid.}}{C^{24}H^{40}O^{5}} + \underset{\text{Glycocine.}}{C^{2}H^{5}NO^{2}}.$$

$$\underset{\text{Taurochloric acid.}}{C^{26}H^{45}NSO^{7}} + H^{2}O = \underset{\text{Cholic acid.}}{C^{24}H^{40}O^{5}} + \underset{\text{Taurine.}}{C^{2}H^{7}NSO^{3}}.$$

Cholic acid does not exist ready formed in normal bile, but is produced from the nitrogenised acids of bile during the putrefaction of that liquid after its removal from the body. Similar changes appear also to take place within the body in certain states of disease; hence, according to Thudichum, it occurs in gall-stones (p. 588).

The easiest mode of preparing cholic acid is to boil the resinous acids precipitated by ether from an alcoholic solution of bile (p. 585) with baryta-water in a retort having its neck directed upwards, adding as much hydrate of barium as will dissolve in the boiling liquid, and continuing the ebullition for about twelve hours. The crystalline mass of hydrate and cholate of barium obtained on cooling, is decomposed by hydrochloric acid, the cholic acid then separating as a glutinous resin, while chloride of barium remains in solution. The cholic acid is suffered to remain in the liquid till it is completely solidified, a few drops of ether being added to accelerate the process, after which it is washed with cold water, dissolved in boiling alcohol or ether, and the solution left to crystallise. Potash may be used in the preparation instead of baryta, but it is less advantageous.

Cholic acid has a bitter taste, with slight saccharine aftertaste. It crystallises in two different forms, and with different quantities of crystallisation-water, according as it is deposited from alcohol or ether.

a. $2C^{24}H^{40}O^{5}.5H^{2}O$. This hydrate is deposited from boiling alcohol. It forms tetrahedral or more rarely octahedral crystals, belonging to the dimetric system. Observed combinations $\frac{P}{2} . \infty P$ and $P . \infty P\infty$. Ratio of principal to secondary axis

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[*] Cholic acid is the name originally proposed by Demarçay. Strecker afterwards altered it to cholalic acid, reserving the term cholic acid for the nitrogenous bile-acid which yields this acid, together with glycocine, by decomposition; but it is more systematic to call this nitrogenised acid glycocholic acid, and retain Demarçay's name for the non-azotised acid.

46 ; P : P, in the terminal edges = 116° 114′; in the lateral edges = 96° 40′. ystals are colourless, very brittle, and have a glassy lustre. In a dry atmo- they lose their water of crystallisation, and become opaque. They dissolve in . of boiling water, in 4000 pts. of cold water, in 20·8 pts. of cold alcohol of cent., and are very soluble in boiling alcohol. The alcoholic solution becomes n addition of water, and after a while deposits shining needles. 1 pt. of cho- (? the $\frac{5}{2}$-hydrate), dissolves in 27 pts. of ether.

$H^{40}O^5.H^2O$. This hydrate is deposited from boiling ether, in crystals belong- the trimetric system, exhibiting the combination ∞P . ∞P̆∞ . P, but having ect of monoclinic crystals, in consequence of the predominance of one half of aces in the same zone. Ratio of brachydiagonal, macrodiagonal, and principal 0·6036 : 1 : 0·3752. Inclination of faces, P : P = 71° 58′; 119° 36′, and ′; P : ∞P = 125° 39′; ∞P : ∞P = 62° 15′; ∞P̆∞; ∞P = 148° 53′. (H.)

two hydrates above described seem to contain different modifications of cholic he dimetric variety gives off all its water at 100° C., and may then be heated without decomposing, whereas the trimetric modification is not easily dehy- at 100°, and melts, with decomposition, at 150°. The two modifications, how- eld the same salts, and are easily converted one into the other.

c acid heated to 200° C. gives off the elements of 1 at. water, and is converted oloïdic acid: $C^{24}H^{40}O^5 - H^2O = C^{24}H^{38}O^4$, and at 290° it is converted in like into dyslysin: $C^{24}H^{40}O^5 - 2H^2O = C^{24}H^{36}O^3$. By distillation, it yields a yel- very acid oil, with only a very slight carbonaceous residue. The oil is soluble and in alkalis: the alkaline solution precipitates metallic salts.

c acid dissolves easily in caustic alkalis, also in hot solutions of alkaline car- , expelling the carbonic acid. The CHOLATES, $C^{24}H^{39}MO^5$, have a very bitter ometimes slightly saccharine; they are soluble in alcohol; those of the earth- and heavy metals are sparingly soluble in water, and may be obtained by ation.

c acid and its salts give with sulphuric acid and sugar the reaction already ed as Pettenkofer's test for bile (p. 586).

late of Ammonium, obtained by passing ammonia-gas into an alcoholic solu- cholic acid and precipitating by ether, forms slender needles, soluble in water. composed by prolonged exposure to the air, with loss of ammonia, more quickly oiled with water.

late of Barium, $Ba''(C^{24}H^{39}O^5)^2$, is obtained by dissolving the acid in baryta- precipitating the excess of baryta by carbonic acid, and concentrating the fil- s a crystalline pellicle mammellated on the surface, silky in the interior. It es in 30 pts. of cold, 23 pts. boiling water, and in a smaller quantity of alcohol. utions are decomposed by a continued stream of carbonic acid. A concentrated n of cholate of potassium yields a white flaky precipitate with chloride of .

late of Calcium, is precipitated in thick clots, which crystallise from ether. *pper-salt* is a bluish-white precipitate. The *lead-salt* is white, sparingly so- n water, soluble in alcohol and acetic acid. The *manganese-salt* is a semi- ine flocculent precipitate. The *mercury-salts* are white precipitates, which e slowly by ebullition.

late of Potassium, precipitated by ether from its alcoholic solution, or ob- by spontaneous evaporation, forms slender needles. From its aqueous solution ecipitated by strong potash. *Cholate of sodium* resembles the potassium-

late of Silver is obtained as a white precipitate, which partly dissolves on , and crystallises as the solution cools. It blackens slightly at 100° C., dissolves n alcohol.

OLOCHROME. The general name for the colouring matters of bile; it in- the ordinary brown bile-pigment called cholophæin or biliphæin; a green nce, cholochloin or biliverdin, produced by oxidation of cholophæin; and fulvin or bilifulvin, a yellow substance found in thickened ox-bile. These nces were first examined by Berzelius (Lehrb. d. Chem. ix. 281), afterwards non, Plattner, Schmid, Scherer and Heintz (Gerh. *Traité*, iv. 532), and ichum (*British Medical Journal*, July 14th, 1860).

lophæin, or the brown pigment, is contained in bile and in the intestinal canal, the substance to which excrements owe their colour. In certain states of disease s in the blood, the serous fluids, the urine, and other liquids of the organism, the cause of the yellow colour of the skin and the cornea in jaundice. It is most conveniently prepared from gall-stones, of which it sometimes forms the chief part, by exhausting them with alcohol, ether, and boiling water; washing the residue with hydrochloric acid, then with water; dissolving it in a weak solution of carbonate of sodium; and precipitating by an acid. As the cholophæin is very apt to pass into the green pigment by oxidation, it is best to perform all these operations in an atmosphere of hydrogen (Heintz). From human gall-stones cholophæin may also be extracted by benzene or by chloroform. (Thudichum.)

Cholophæin recently precipitated is a brown amorphous substance, becoming darker when dry. It is infusible, insoluble in boiling water; soluble in boiling alcohol, the solution gradually turning green by contact with the air. Hydrochloric acid dissolves it in small quantity, acquiring a blue colour. On adding excess of ammonia, the liquid immediately acquires a greenish-yellow colour, which is changed to red by nitric acid.

Cholophæin contains, according to Heintz's analysis, 60·9 per cent. carbon, 6·05 hydrogen, and 9·1 oxygen, whence may be deduced the empirical formula, $C^{16}H^{18}N^{2}O^{4\cdot5}$ (61·9 C, 58 H, 9·0 N, and 23·2 O).

Caustic alkalis and alkaline carbonates dissolve cholophæin with brownish-yellow colour: the ammoniacal solution yields a brown flaky precipitate with chloride of barium or chloride of calcium. A solution of cholophæin in very dilute alcoholic potash assumes a green colour on addition of hydrochloric acid; and if nitric acid be then added drop by drop, a fine blue colour is produced, which lasts a long time.

Cholochloïn or *Biliverdin.*—This green pigment is produced by the oxidation of cholophæin. An alkaline solution of the latter gradually oxidises by exposure to the air, and, if then treated with acids, yields a green precipitate. Cholochloïn exists ready formed in ox-bile, and is abuudant in that of birds, fishes, and amphibia.

Thudichum obtains the green pigment by allowing bile to stand in well-closed bottles for two years, whereupon a putrefactive decomposition ensues (p. 587), and cholochrome is precipitated, together with cholic acid and other substances. The precipitate, after decantation of the liquid, is put into a calico-bag and washed with water as long as the liquid will pass through; then boiled with alcohol and washed on a filter with large quantities of that liquid, which removes cholic acid and its salts, also fats and fatty acids. The colouring matter then remains, mixed with mucus, from which it may be freed by solution in carbonate of sodium. The alkaline solution, treated with hydrochloric acid, throws down a substance of a fine green colour, which however is probably still somewhat impure.

Cholochloïn is destitute of taste and odour. It does not melt when heated, but decomposes at a high temperature, leaving a large quantity of carbon. It is insoluble in cold, slightly soluble in boiling water; easily soluble in alkalis, also in alcohol.

According to Heintz, cholochloïn contains 60·04 per cent. C, 5·84 H, 8·53 N, and 25·59 O, whence is deduced the empirical formula $C^{8}H^{9}NO^{2\cdot5}$, requiring 60·38 C, 5·66 H, 8·80 N, and 25·16 O. Cholochloïn forms with baryta a green amorphous compound, containing 27·3 per cent. baryta.

The formulæ of cholophæin and cholochloïn, as deduced from their analyses, are very uncertain. Thudichum found 60 to 62 per cent. carbon in cholophæin from gall-stones, and as much as 66 per cent. in that prepared from bile. Probably both modifications contain the same number of carbon-atoms, the green compound containing more oxygen than the brown: thus cholophæin = $C^{8}H^{9}NO^{2\cdot25}$, and cholochloïn $C^{8}H^{9}NO^{2\cdot5}$, or possibly $C^{8}H^{9}NO^{2}$ and $C^{8}H^{9}NO^{3}$.

CHOLOCHROMIC ACID. When nitric acid containing nitrous acid, is added to a dilute solution of cholochrome (either brown or green) in an aqueous alkali, the colour of the liquid changes to green, blue, violet, red, and finally to yellow. These changes of colour are connected with the formation of a non-azotised acid, which, according to Thudichum, may be obtained by passing nitrous acid vapours into water in which cholophæin is suspended. Effervescence then takes place, arising from evolution of nitrogen; the colour of the bile-pigment changes from brown to red; and on subsequently shaking it up with ether, a red solution is obtained, which on evaporation leaves a pink syrupy residue, consisting of the non-azotised acid, *cholochromic acid.* It dissolves easily in chloroform, and the solution, when evaporated in an atmosphere of coal-gas, and afterwards left to stand for some days in a flask filled with the same gas, deposits the acid, partly in flat rhombic octahedrons, partly in groups of radiating needles, partly as an amorphous mass.

Thudichum assigns to this acid the formula $C^{16}H^{18}O^{7}$, or $C^{8}H^{9}O^{3\cdot5}$. It should perhaps be $C^{8}H^{8}O^{3}$, in which case its formation from cholophæin might be represented by the equation:

$$C^{8}H^{9}NO^{2} + HNO^{2} = C^{8}H^{8}O^{3} + N^{2} + H^{2}O,$$

the reaction being that of nitrous acid on an amic acid (p. 168).

Cholochromic acid is nearly insoluble in cold water, but easily soluble in alcohol:

ion has an acid reaction, and precipitates metallic salts. The lead-salt has a silver-salt a pink colour.

LOÏDANIC ACID. $C^{16}H^{24}O^{7}$ (?)—The residue in the retort obtained in choloïdic acid with nitric acid, separates on cooling into two layers, the upper is crystalline, and consists of choloïdanic acid. The crystalline crust is on a funnel containing pounded glass, and purified by recrystallisation from water. Should the residue in the retort be merely a resinous mass, it must er subjected to the action of nitric acid, which will finally convert it into the ne acid.

ïdanic acid crystallises in long hair-like prisms, which, after drying on paper, aspect of asbestos. It is nearly insoluble in cold water, and but sparingly n boiling water; easily soluble in alcohol: the solutions are acid. It does weight at 100° C.; but at a higher temperature it blackens and gives off an d vapour. It dissolves without alteration in hot nitric or hydrochloric acid. ïdanic acid requires a large quantity of alkali to saturate it. The choloïdanates kali and alkaline earth-metals are soluble in water; the rest are insoluble or soluble. They are all decomposed by washing with water.

LOÏDIC ACID. $C^{24}H^{38}O^{4}$.—This acid was discovered by Demarçay, and further examined by Theyer and Schlosser and by Strecker (see refe. 926). It is produced by the dehydration of cholic acid at 200° C., and, g to the observations of Gorup-Besanez and of Thudichum (p. 587), is one of ucts of the putrefaction of bile: hence also it is found in gall-stones. It may red directly from bile by boiling that liquid, dissolved in 12 to 15 pts. water, ess of hydrochloric acid for three or four hours, and leaving the liquid to cool. acid then collects at the bottom in a solid mass, which must be several times with water to remove the hydrochloric acid, then pulverised, dissolved in a antity of alcohol, shaken up with ether to free it from cholesterin and margaric finally evaporated to dryness over the water-bath. If the action of the hydrocid be too long continued, dyslysin is obtained instead of choloïdic acid çay). Choloïdic acid is likewise obtained by digesting bile with oxalic acid. r and Schlosser.)

dic acid is a white non-crystalline substance, which melts in boiling water dissolving to a sensible amount. After drying it requires a heat of more than o melt it. It is very soluble in alcohol; water renders the solution milky, rates the acid in the form of a resin; the solution has an acid reaction. It gly soluble in ether.

dic acid unites with bases and decomposes carbonates with aid of heat. The s of the alkali-metals are soluble in water and alcohol, insoluble in ether; e a pure bitter taste without any sweetish after-taste. By evaporation they ned in the form of gummy masses. The salts of the earth-metals and heavy e insoluble or sparingly soluble in water, insoluble in alcohol, and are ob- the form of plastic precipitates. The *barium-salt*, $C^{48}H^{74}Ba''O^{8}.4H^{2}O$ (at is insoluble in water and amorphous. The *silver-salt*, $C^{24}H^{37}AgO^{4}$ (at 100° C.), y white precipitate, which undergoes considerable contraction and coloration g.

dic acid is oxidised by strong nitric acid, yielding a great number of products. choloïdic acid be treated in a tall vessel with 4 or 5 vol. strong nitric acid, the stilled to one-fifth, after the first violent action has subsided, cohobating ary, and the liquid, when the action has ceased, diluted with twice its bulk and again distilled, a distillate is obtained having a very acrid suffocating rising from the presence of a heavy oil, consisting of nitrocholic acid, (?), and cholacrol, while on the surface of the watery liquid there floats l, which is a mixture of acetic, valeric, caprylic, and capric acid. The residue etort is a yellowish mixture of oxalic, cholesteric, and choloïdanic acids. abacher, Ann. Ch. Pharm. lvii. 145.)

LONIC ACID. $C^{26}H^{41}NO^{5}$. (Strecker, Ann. Ch. Pharm. lxvii. 1.—Mulder, *h. über die Galle.*—Gerh. iv. 722.)—This acid, which is homologous with ocholic acid ($C^{27}H^{43}NO^{5}$), is produced by the action of strong acids upon ic acid, from which it differs only by the elements of 1 at. water.

a solution of glycocholic acid in strong sulphuric or hydrochloric acid is heated, es turbid and yields oily drops, which solidify and become resinous on cooling; eating this resinous product with baryta-water, and decomposing the insoluble alt with hydrochloric acid, cholonic acid is separated, and may be obtained in needles by crystallisation from alcohol.

ate of Sodium, $C^{26}H^{40}NaNO^{5}$, is crystallisable

In preparing cholonic acid by the action of hydrochloric on glycocholic acid, another acid is sometimes formed containing 1 at. H^2O less. (Strecker.)

CHONDRIN. $C^{16}H^{26}N^{2}O^{7}$. (J. Müller, Pogg. Ann. xxxviii. 305.—F. Simon, J. Chem. méd. i. 108.—Vogel, J. pr. Chem. xxi. 426.—Hopp, *ibid.* lvi. 129).—A substance resembling gelatin in many of its properties, and long confounded with it: its separate identity was first established by Müller.

Chondrin, like gelatin, does not occur ready formed in the organism, but is produced by boiling certain tissues with water. All permanent cartilages in a healthy state yield chondrin when boiled with water; so does bone-cartilage or ossein before ossification; but bone-cartilage after ossification yields gelatin by boiling: so likewise do the tendons, skin, calves' feet, hartshorn, isinglass, and fish scales; also the permanent cartilages when they become ossified by disease.

Chondrin may be prepared by boiling the cartilages of the ribs, larynx, or joints with water for about forty-eight hours, evaporating the liquid to a jelly, and treating this residue with ether to free it from fat. The cornea of the eye yields the same substance.

Chondrin, when dried, is a hard, horny, diaphanous substance, which softens to a jelly in cold water, and dissolves completely in boiling water; it is insoluble in alcohol and in ether. The aqueous solution, when boiled for a long time, yields a substance perfectly soluble in cold water, but resembling chondrin in all its other reactions.

Nearly all acids, even organic acids, precipitate chondrin from its aqueous solution. The precipitate formed by hydrochloric, sulphuric, nitric, phosphoric, phosphorous, chloric, or iodic acid, redissolves easily in excess of the acid; that formed by sulphurous, pyrophosphoric, hydrofluoric, carbonic, arsenic, acetic, tartaric, oxalic, citric, lactic, or succinic acid does not redissolve in excess of the acid employed. Strong sulphuric acid dissolves chondrin, forming a syrupy liquid, which, when diluted with water and boiled, yields leucine without glycocine (Hopp). Sulphurous acid slowly decomposes chondrin. Nitric acid, by prolonged action, converts it into *xantho-proteic acid.*

Alum, sulphate of aluminium, acetate and subacetate of lead, sulphate of copper, ferrous and ferric sulphates, ferric chloride, mercurous and mercuric nitrates, produce copious precipitates in a solution of chondrin, soluble for the most part in excess of the reagent. Ferrocyanide of pota-sium produces no precipitate. The precipitates formed by acetic acid, alum, and sulphate of aluminium dissolve completely on adding a sufficient quantity of acetate of potassium (or of sodium) or common salt. The precipitate formed by ferric sulphate redissolves on heating the liquid. Mercuric chloride does not precipitate a solution of chondrin; sometimes a slight turbidity is produced, owing apparently to the presence of a little gelatin.

Chondrin is especially distinguished from gelatin by its precipitation by alum, sulphate of aluminium, acetate of lead, the sulphates of iron and sulphate of copper, and by its non-precipitation by mercuric chloride. (See GELATIN.)

The aqueous solution of chondrin treated with chlorine, yields a precipitate containing $C^{16}H^{23}ClN^{4}O$ (?) (Schröder.)

By dry distillation chondrin yields the same products as gelatin (*q. v.*)

Mulder (Ann. Ch. Pharm. xxviii. 328) found in chondrin from human cartilage, 49·3 per cent. C, 6·6 H, 14·4 N, and 0·4 sulphur. Schröder also found in chondrin from the cartilages of the cow, 49·3 carbon and 6·6 hydrogen.

CHONDRODITE. *Hemiprismatic Chrysolite, Maclureite, Humite, Brucite* (in part).—A silicate of magnesium containing fluorine; sometimes occurring in small implanted crystals, but more frequently in crystalline grains or masses of somewhat granular structure, imbedded in granular limestone, as at Pargas in Finland, at Aker and Gulsjö in Sweeden, in Sussex County, New Jersey, in Orange County, New York, and other localities. The variety called *humite* is from Vesuvius, where it occurs in ejected masses of a kind of granite rock, together with olivine, mica, and magnetite.

The crystals belong to the trimetric system, and are often hemihedral in octahedral planes, producing forms of monoclinic character; $\infty P : \infty P = 94° 26'$. They are of three types, in which the axes have the following ratios:

	Macrodiagonal.		Brachydiagonal.		Principal axis.
Type I.	1·4678	:	1	:	1·0806
Type II.	1·5727	:	1	:	1·0806
Type III.	1·4154	:	1	:	1·0806

Compound crystals also occur. Cleavage indistinct. Specific gravity 3·118 to 3·22. Hardness 6 to 6·5. Colour yellow or brown, inclining to red and green, with waxy or glassy lustre; more or less translucent. It is scarcely fusible before the blowpipe, gives the reactions of fluorine when heated with sulphuric acid, and with fluxes the s of iron and silica. Dissolves in hydrochloric acid, with separation of gelatinous

ses.—1. Seybert (Sill. Am. J. v. 336.—2, 3, 4. Rammelsberg (*Mineral-*
p. 443).—5. Fischer (Sill. Am. J. [2] ix. 85.—6, 7, 8. Rammelsberg (*loc.*

	SiO^2.	Mg''O.	Fe''O.	Fe^2O^3.	F.	
w Jersey . . .	32·66	54 00	—	2·33	—	HF 4·09; H^2O 1·0; K^2O 2·11
„ *yellow* .	33·06	55·46	2·65	—	7 60 =	99·77
rgas, *yellow* . .	33·10	56·61	2·35	—	8·69 =	100·75
„ *grey* . . .	33·19	54·50	6·75	—	9·69 =	103·13
w Jersey, *red* . .	33·35	53·06	5·50	—	7·60 =	99·50
mite, type I. . .	34·80	60·08	2·40	—	3·47 =	100·75
				Ca''O.		
„ type II. . .	33·26	57 92	2·30	0·70	5·04	Al^4O^3 = 1·06 = 100·38
„ type III. . .	36·67	56·83	1·67	—	2·61 =	97·78

analyses lead to the formula $8Mg''O.3SiO^2 = (Mg'')^8Si^3O^{14} = 2Mg''O.3Mg^2SiO^4$,
part of the oxygen is replaced by fluorine; or the mineral may be represented
up of the two compounds:

$$Mg^8Si^3F^{28}, \text{ or } 8Mg''F^2.3SiF^4 = A$$
$$Mg^8Si^3O^{14}, \text{ or } 8Mg''O.3SiO^2 = B$$

us proportions, namely:

Chondrodrite from Finland and North America	=	$A + 12B$
Humite from Vesuvius, type I.	=	$A + 18B$
„ „ type II.	=	$A + 27B$
„ „ type III.	=	$A + 36B$

dite occurs altered to serpentine at Sparta, New Jersey, with spinel and mica
ii. 186.)

NDROGEN. A name applied to the tissues which yield chondrin when
ith water, or rather to the substance which may be regarded as the basis of
sues.

NDROITES. Concretions occurring in the cavities and channels of the
body which are lined with mucous membranes, especially in the nose, gullet,
and bronchiæ: they are produced, under abnormal circumstances, from the
n of these membranes, their nucleus being sometimes a solid body accidentally
in these cavities. They contain very variable quantities of water and animal
together with 50—80 per cent. of phosphate of calcium, 6—20 per cent. car-
of calcium, 8—12 per cent. carbonate of magnesium, and small quantities of
salts. (Handw. d. Chem. ii. [2] 1196.)

NICRITE. A dense non-crystalline mineral from Elba, of specific gravity
ardness 3. Fracture conchoïdal. White. Translucent at the edges. Melts
derable facility to a greyish-white glass, evolving bubbles of gas at the same
blue glass with cobalt-solution. Dissolves slowly in borax, yielding a glass
coloured by iron. Easily decomposed by concentrated hydrochloric acid, with
ion of silica, not in the usual gelatinous state. According to Kobell's analysis,
ins 12·6 lime, 22·5 magnesia, 1·46 ferrous oxide, 17·12 alumina, 35·7 silica, and
er, a composition which may be approximately represented by the formula:
$).SiO^2).2(2Al^2O^3.3SiO^2) + 12$ aq., which by substituting $al = \frac{2}{3}$ Al, may be re-
o $3(M'')^2SiO^4.2(al'')^2SiO^4 + 4$ aq. (*Rammelsberg's Mineralchemie*, p. 858.) Dana
chonicrite as a variety of pyrosclerite (*q. v.*).

ISMATIN. A viscid translucent resin from Wettin near Halle, where it
as a coating on calcspar in a fissure. It has a shining lustre, and varies in
rom yellow to olive-green. Burns with flame and without odour. (Germar,
e geol. Zeitschr. i. 40.)

ISTIANITE. See PHILLIPSITE.

OMATES. Chromic acid unites with nearly all bases. The salts are for
t part easily crystallisable and isomorphous with the corresponding sulphates.
omates of the alkali-metals, and of strontium, calcium, and magnesium, are
in water: the others are insoluble, or sparingly soluble.

the alkali-metals, chromic acid forms two series of salts, namely, neutral or
chromates, M^2CrO^4, or $M^2O.CrO^3$, which are yellow, and acid chromates, com-
called bichromates, $M^2CrO^4.CrO^3$, or $M^2O.2CrO^3$, which have an orange-red
a hyperacid chromate, or trichromate of potassium, $K^2CrO^4.2CrO^3$, or $K^2O.3CrO^3$,
ise known. These salts are produced, either by direct saturation of the base
romic acid, or by igniting chromic oxide with an alkali and a nitrate or other
g agent.

insoluble chromates are obtained by precipitation. Most of them are basic.
which contain 3 at. basic metal to 1 at. chromium, may be called orthochro-

mates, M^6CrO^6, or $3M^2O.CrO^3$, the ordinary neutral chromates M^2CrO^4, which differ from them by $2M^2O$, being metachromates.

A solution of an alkaline chromate gives with a salt of *barium*, *lead*, or *bismuth*, a yellow precipitate: with *mercurous* salts a brick-red, and with *silver*-salts, a red-purple precipitate: all these precipitates are soluble in nitric acid. Chromates boiled with excess of *hydrochloric* acid, yield a green solution of sesquichloride of chromium. A chromate of alkali-metal boiled with sulphuric acid and a reducing agent, such as *sugar*, *alcohol*, or *tartaric acid*, yields a purple or a green solution of a chromic alum. Chromates heated with *sulphuric acid and common salt*, give off yellowish-red vapours of oxychloride of chromium. The chromates of the less basic metals give off oxygen when ignited, and leave chromic oxide: the acid chromates of the alkali-metals leave a mixture of chromic oxide and neutral chromate. Insoluble chromates fused with *nitre*, yield chromate of potassium, which may be dissolved out by water.

Chromates in solution have a bitter metallic taste, and a poisonous action.

Chromates of Ammonium.—The *neutral salt* $(NH^4)^2CrO^4$, is obtained by evaporating a mixture of chromic acid with excess of ammonia, or by decomposing chromate of barium with sulphate of ammonium. Hirzel (Zeitschr. f. Pharm. 1852, p. 24), gradually adds oxychloride of chromium to excess of ammonia, and evaporates the solution at 60° C. Chromate of ammonium then crystallises out, and may be purified by recrystallisation. It forms lemon-yellow needles, permanent in the air; has a pungent taste and alkaline reaction. It is very soluble in water. Leaves chromic oxide when ignited.

Acid salt, $(NH^4)^2CrO^4$, or $(NH^4)^2O.2CrO^3$.—Obtained by dividing a solution of chromic acid into two parts; saturating one with ammonia, then adding the other, and evaporating the whole over sulphuric acid. It forms orange-coloured crystals, permanent in the air, soluble in water, and yielding green chromic oxide when ignited. (Richmond and Abel, Chem. Soc. Qu. J. iv. 199.)

Darby (*ibid.* i. 20), by partially saturating chromic acid with ammonia and evaporating to the crystallising point, obtained a compound of ammonia with chromic anhydride $2NH^3.CrO^3$, which may be regarded as a *chromamate of ammonium*, $\left.\begin{matrix}NH^2(CrO^2)''\\NH^4\end{matrix}\right\}O$, analogous to sulphamate of ammonium, $\left.\begin{matrix}NH^2(SO^1)''\\NH^4\end{matrix}\right\}O$.

Hyperacid salt, $(NH^4)^2CrO^4.5CrO^3 + 10$ aq., or $(NH^4)^2O.6CrO^3 + 10$ aq.—Brown-yellow, very efflorescent salt, obtained in ill-defined crystals by evaporating a solution of chromic acid half neutralised with ammonia. (Rammelsberg, Pogg. Ann. xciv. 507.)

A compound of *chromic anhydride and sal-ammoniac*, $NH^4Cl.CrO^3$, is obtained by adding oxychloride of chromium to a strong solution of sal-ammoniac, in crystals having the same form and aspect as the corresponding potassium-compound, but much more soluble in water. (Péligot, Ann. Ch. Phys. [2] lii. 267.)

Chromate of Barium.—The *neutral chromate*, $Ba''CrO^4$, is prepared by precipitating chromate of potassium with chloride of barium or baryta-water. It is insoluble in water, but dissolves, with reddish-yellow colour, in nitric, hydrochloric, or excess of chromic acid, and is precipitated from the solution by ammonia. It is decomposed by alkaline carbonates and sulphates, even at ordinary temperatures, and more quickly when heated. It is used as a pigment called *yellow ultramarine*.

Acid salt, $Ba''CrO^4.CrO^3$, or $Ba''O.2CrO^3$.—A concentrated solution of the neutral salt in chromic acid is decomposed by dilution, part of the salt being precipitated, while an acid salt remains in solution, and may be obtained by evaporation in yellowish-brown stellate crystals, containing $Ba''O.2CrO^3 + 2$ aq., which dissolve slowly in water, with separation of the neutral salt. (Babo, J. pr. Chem. lx. 60.)

Chromate of Bismuth.—When a solution of nitrate of bismuth is added to a moderately concentrated solution of acid chromate of potassium, leaving the latter slightly in excess, an egg-yellow, flocculent precipitate is formed, which afterwards becomes dense and crystalline. It consists of $3Bi^2O^3.2CrO^3$ or $7Bi^2O^3.2Bi^2Cr^3O^{12}$. It is insoluble in water, may be dried without decomposition at 100° to 125° C., but acquires a dark green colour when ignited, and retains this colour after cooling. It dissolves in nitric or hydrochloric acid, forming a deep yellow liquid, which becomes turbid on dilution, from precipitation of basic nitrate or chloride of bismuth. If it be treated with a small quantity of acid, a yellow salt remains undissolved, consisting of $Bi^2O^3.2CrO^3$ or $Bi^2O^3.2Bi^2Cr^3O^{12}$. The latter may also be obtained by precipitating acid chromate of potassium with a slightly acid bismuth-solution (J. Löwe, J. pr. Chem. lxvii. 288, 463). According to Pearson (*ibid.* lxviii. 255), the precipitate formed in the latter case is $Bi^2O^3.CrO^3$, and is perfectly insoluble in water, so that it may be conveniently used for the estimation of bismuth.

OMATE OF CADMIUM.—A basic salt, $5Cd''O.2CrO^3 + 8$ aq., or $3Cd''O.2Cd''CrO^4$
is obtained as an orange-yellow precipitate, on mixing a cadmium-salt with
chromate of potassium. On adding ammonia, the salt $(NH^4)^2CrO^4.(N^2H^6Cd)''O$
s obtained, which crystallises in transparent, bright-yellow, six-sided pyramids,
sing when exposed to the air or immersed in water.

OMATE OF CALCIUM.—The *neutral* salt, $Ca''CrO^4 + 4$aq., is obtained by dis-
carbonate of calcium in aqueous chromic acid, or as a light yellow precipitate
g concentrated solutions of chromate of potassium and chloride of calcium.
derately soluble in water, insoluble in alcohol; gives off its water at 200° C.,
fterwards very sparingly soluble. The anhydrous salt is used as a pigment.
l salt obtained by dissolving the neutral salt in aqueous chromic acid and
ing, forms red deliquescent crystals, containing $Ca''CrO^4.CrO^3 + 3$aq.
nate of Calcium and Potassium, $(KCa)Cr^2O^4 +$ aq., obtained by saturating acid
e of potassium with hydrate of calcium, forms lemon-yellow, silky crystals.

OMATE OF CERIUM, $Ce''CrO^4$, is deposited as a yellow powder from a solution
nate of cerium in chromic acid. The filtrate yields on evaporation an acid salt
risms, soluble in water.

OMATE OF CHROMIUM.—The brown oxides of chromium intermediate be-
e sesquioxide Cr^2O^3, and chromic anhydride, CrO^3, may be regarded as com-
of these two in various proportions, that is, as chromates of chromium. (See
UM, OXIDES OF.)

OMATE OF COBALT.—Solutions of cobalt-salts form with chromate of potas-
ight red-brown precipitate containing, according to Sarzeau and Malaguti
. Phys. [3] ix. 431), $CO^3CrO^6 + 4$aq., which is the formula of an orthochromate.

OMATES OF COPPER.—When impure cupric hydrate is immersed in a strong
of chromic acid, a brown solution is formed which deposits a brown powder,
a tetrabasic salt, $4Cu''O.2CrO^3$, or $2Cu''O.2Cu''CrO^4$ (Dröge, Ann. Ch. Pharm.
The solution filtered through asbestos, and evaporated over oil of vitriol,
fter a while, green crystals, consisting, according to Kopp (*ibid.* lvii. 386), of
lphate in which part of the sulphuric acid is replaced by chromic acid (H^2SO^4
O^4, or S by Cr). The mother-liquor decanted therefrom, is free from sul-
cid, and yields by evaporation, acid cupric chromate, $Cu^2CrO^4.CrO^3$
n brown-black, deliquescent crystals, soluble in alcohol and in ammonia. The
solution deposits on boiling a brown insoluble salt. The crystals give off
er at 100° C., and at a red heat the salt is completely decomposed. The
c salt above mentioned is deposited as a chocolate-brown precipitate, contain-
water, on mixing a boiling solution of neutral chromate of potassium with
phate of copper. (Malaguti and Sarzeau.)
monio-chromate of copper, $5NH^3.Cu''O.2Cu''CrO^4 +$ aq., is obtained in dark green
crystals, by passing ammonia-gas into water in which tetrabasic chromate of
suspended, and cooling the liquid below 0° C. It soon gives off its ammonia
posed to the air: and is resolved by water into insoluble basic chromate of
nd a basic ammonio-chromate which dissolves in the water with emerald-
our. The same basic ammonio-chromate is obtained by treating acid cupric
with ammonia.
ate of Copper and Potassium, $K^2O.3Cu''O.3CrO^3 + 3$aq., or $Cu''H^2O^2.(K^2Cu^2$
2aq., is obtained by treating recently precipitated cupric hydrate with solution
hromate of potassium, or by mixing a solution of cupric sulphate with acid
of potassium, and gradually adding caustic potash. The product is a light
wder, consisting of microscopic, translucent, six-sided tablets, nearly insoluble
but dissolving with deep green colour in ammonia or carbonate of ammo-
The solution, if saturated while hot, deposits on cooling green prisms having a
stre.

MATE OF GLUCINUM is a yellow insoluble precipitate.

MATE OF IRON.—Aqueous chromic acid digested with moist ferric hydrate,
brown solution, containing $Fe^2O^3.4CrO^3$. The solution is not rendered turbid
dilution or by boiling, and yields on evaporation a brown resinous residue,
n water and in alcohol. The *basic salt* is a brown powder, which is resolved
into ferric oxide and chromic acid.

MATES OF LEAD.—The neutral or metachromate, $Pb''CrO^4$, is found native as
ore, *Crocoisite*, or *Lehmannite*, in monoclinic prisms, in which the ratio of the
gonal, clinodiagonal, and principal axis is as 1·041 : 1 : 0·96, and the inclina-
he principal axis to the clinodiagonal, 77° 30′. The predominant faces are
∞P and $-P$. Cleavage most distinct parallel to ∞P. Specific gravity
. Hardness 2·5 to 3. The crystals are translucent and of a yellow colour,

with various shades of bright hyacinth-red; streak orange-yellow. Sectile. It occurs in decomposed gneiss or granite, at Nischne Tagilsk in the Ural, in Brazil, at Retzbanya in Hungary, at Moldawa in the Bannat, and in Luzon, one of the Phillippine Isles.

Neutral chromate of lead is obtained as a light yellow insoluble precipitate, by mixing a dilute solution of a neutral lead-salt with neutral or acid chromate of potassium; concentrated solutions yield an orange-yellow precipitate. It may also be obtained by decomposing sulphate or chloride of lead with chromate of potassium. It is insoluble in water, slightly soluble in nitric acid, easily in potash. At a moderate heat, it melts without decomposition to a brown mass, exhibiting a radiated structure when cold, and yielding a dark yellow, slightly hygroscopic powder. At a full red heat, it gives off oxygen, and is reduced to a mixture of basic chromate of lead and chromic oxide. Heated in a stream of hydrogen gas, it gives up 12 per cent. oxygen, and is reduced to a mixture of chromic oxide and metallic lead, which when heated in a stream of oxygen takes up 7 per cent. of that gas. (On the use of chromate of lead in organic analysis, see pp. 227, 232.)

Chromate of lead is much used as a pigment, known as chrome-yellow, also *lemon-yellow*, *Leipsig yellow*, *Paris yellow*, &c. The finer sorts are prepared by precipitation, the commoner kinds by decomposing carbonate, chloride, or sulphate of lead (obtained as a by-product in the preparation of alum-mordants), with chromate of potassium. According to Anthon, 100 pts. sulphate of lead require for decomposition 25 pts. of red chromate of potassium, and 100 pts. chloride of lead require 27 pts. of red chromate. Chrome-yellow exhibits various shades of red and yellow, according to its mode of preparation: it is often mixed with chalk, gypsum, heavy spar, clay, sulphate of lead, &c. *Cologne yellow* is a mixture of chromate and sulphate of lead with sulphate of calcium, obtained by precipitating a mixture of the nitrates of lead and calcium with a mixture of sulphate of sodium and chromate of potassium. It is not altered by exposure to air or light; sulphuretted hydrogen turns it brown; protochloride of tin and sulphurous acid reduce it; alkalis turn it orange or red, by formation of basic chromate of lead. It is used as an oil or water-colour, for lacquering, and may be mixed with many other colours without decomposition; with Prussian blue it forms a green mixture, called chrome-green, or green cinnabar. In calico-printing, chrome-yellow is formed on the fabrics themselves, by first steeping them in a solution of lead-salt, then in chromate of potassium. For dyeing silk and wool it is not so well adapted.

Basic Chromate of Lead.—A *dibasic* or *tetraplumbic chromate*, $2Pb''O.CrO^3 = Pb''O.Pb''CrO^4$, known in the arts as chrome-red, is produced from the neutral chromate by digesting it with caustic alkalis, or with levigated oxide of lead, or by boiling it in the recently precipitated state with neutral chromate of potassium, or by fusing it with nitre. It is of a deep orange or red colour, according to the mode of preparation. The finest vermilion-red chromate is formed when 1 pt. of chrome-yellow is thrown into 5 pts. of nitre in a state of fusion, and the resulting chromate of potassium, together with the excess of nitrate, dissolved out by water: the basic chromate of lead then remains in the form of a crystalline powder (Liebig and Wöhler). An orange pigment may be obtained very economically, by boiling the sulphate of lead, which is a waste product in making acetate of alumina from alum by means of acetate of lead, with a solution of chromate of potassium. The basic chromate of lead, forms a beautiful orange upon cloth, which is even more stable than the yellow chromate, not being acted upon by either alkalis or acids. One method of dyeing chrome-orange, is to fix the yellow chromate of lead in the calico, by dipping it successively in acetate of lead and acid chromate of potassium, and then washing it. This should be repeated, in order to precipitate a considerable quantity of the chromate in the calico. A milk of lime is then heated in an open pan; and when it is at the point of ebullition, the yellow calico is immersed in it, and instantly becomes orange, being deprived of a portion of its chromic acid by the lime, which forms a soluble chromate of calcium. At a lower temperature, lime-water dissolves the chromate of lead entirely, and leaves the cloth white.

A *sesquibasic* or *hexplumbic chromate*, $3PbO.2CrO^3 = PbO.2PbCrO^4$, is found native as *Melanochroïte*, *Phœnicite*, or *Phœnikochroite*, at Beresof in the Ural, associated with crocoisite, vauquelinite, pyromorphite, and galena. It occurs in tabular crystals, apparently belonging to the trimetric system, reticularly interwoven; cleaving perfectly in one direction; also massive. Specific gravity 5·75. Hardness 3 to 3·5. It has a resinous or adamantine, glimmering lustre, cochineal or hyacinth-red colour, becoming lemon-yellow on exposure to the air. Streak brick-red. Subtranslucent or opaque.

A *chromate of lead and copper*, of analogous composition, viz. $\left.\begin{matrix}Pb^{\frac{2}{3}}\\Cu^{\frac{1}{3}}\end{matrix}\right\}O.2\left(\begin{matrix}Pb^{\frac{2}{3}}\\Cu^{\frac{1}{3}}\end{matrix}\right)CrO^4$, called *Vauquelinite*, occurs at Beresof, at Pont Gibaud in the Puy de Dôme, and

he crocoisite of Brazil, in monoclinic crystals, usually minute and irregularly
gated; also reniform or botryoïdal, and granular; amorphous. Specific gravity
5·78. Hardness 2·5 to 3. It has a dark green to brown colour, sometimes nearly
with adamantine or resinous lustre, often faint. Streak, siskin-green or brownish.
y translucent or opaque. Fracture uneven. Rather brittle. (Dana, ii. 360.)

ROMATE OF LITHIUM, Li^2CrO^4, crystallises in orange-yellow, oblique rhombic
s, easily soluble in water.

ROMATE OF MAGNESIUM, $Mg''CrO^4 + 7aq.$, obtained by evaporating a solution
gnesia in chromic acid, forms lemon-yellow crystals isomorphous with sulphate
gnesium. Specific gravity = 1·66 at 15° C.

omate of Magnesium and Ammonium, $Mg''(NH^4)^2Cr^2O^8 + 6aq.$, is isomorphous
he corresponding sulphate.

ROMATES OF MANGANESE.—A *manganic* salt, $3(Mn^2O^3.CrO^3).Cr^2O^3 + 6aq.$,
cipitated on mixing sesquichloride of manganese with chromate of potassium.
rie, Chem. Soc. Qu. J. iv. 300.)

asic manganous chromate, $2Mn''O.CrO^3 + 2aq. = Mn''O.Mn''CrO^4$, is obtained as a
lline precipitate on mixing manganous sulphate with neutral chromate of potas-
It is brown, translucent, and dissolves with orange-yellow colour in sulphuric
itric acids (Warington, *L'Institut*, No. 513, p. 366.—Reinsch, Pogg. Ann.
). According to Fairrie, it contains chromic oxide.

ROMATES OF MERCURY.—*Mercuric metachromate*, $Hg''CrO^4$, is obtained
iling equal parts of chromic anhydride and yellow mercuric oxide in water,
radually evaporating till the mercuric oxide disappears, and red crystals are
d in its place: the mother-liquor yields an additional quantity by concentration.
ms dark garnet-red rhombic prisms, becoming darker-coloured when heated.
are decomposed by water, even in the cold, and completely when heated, yield-
ee chromic acid and amorphous *mercuric orthochromate*, Hg^3CrO^6. They dis-
readily in hydrochloric acid, and potash added to the solution throws down yellow
ric oxide, or perhaps the orthochromate. Strong nitric acid converts them, in
old, into an amorphous yellow compound, a large portion however dissolving;
ately strong nitric acid and dilute sulphuric acid act in the same manner, ex-
g that a larger quantity of the yellow compound remains undissolved.

rcuric orthochromate, Hg^3CrO^6, or $3Hg''O.CrO^3$, is obtained as a brick-red pow-
adding mercuric nitrate to acid chromate of potassium; or by boiling yellow
ric oxide with chromate of potassium (Millon). It is also produced, together
a less basic salt, by precipitating the mother-liquor of the metachromate with
ate of sodium. On boiling the precipitate with soda-ley, an amorphous, yellow,
powder is precipitated, which appears to consist of $7Hg''O.2CrO^3$, or
$2Hg^3CrO^6$. The same salt appears also to be obtained by boiling recently pre-
ted mercuric oxide with acid chromate of potassium, till it is converted into a
red powder, washing this powder repeatedly by decantation, and heating it with
ately strong nitric acid. It dissolves in strong nitric acid only when recently
itated; strong sulphuric acid, with aid of heat, converts it into white mercuric
ate: hydrochloric acid does not dissolve it. (Geuther, Ann. Ch. Pharm. cvi.

etrabasic mercuric chromate, $4Hg''O.CrO^3$, or $3Hg''O.Hg''CrO^4$, of dark violet or
colour, is said to be obtained by boiling red mercuric oxide with chromate of
ium. When equivalent quantities of basic mercuric chromate and solution of
le of mercury and potassium are boiled together for some time, oxycyanide of
ry separates first, and afterwards a compound containing K^2HgCy^4 and $HgCrO^4$.
ther.)

rcurous chromate, $(Hg^2)''O.CrO^3 = (Hg^2)^2CrO^4$, is obtained as a brilliant red
lline powder, by boiling the basic salt next to be described, with a small quantity
ute nitric acid, or the double salt of cyanide of mercury and chromate of potas-
with mercurous nitrate.

ic mercurous chromate, $2(Hg^2)''O.CrO^3 = (Hg^2)''O.(Hg^2)''CrO^4$, is obtained as a
red powder by precipitating mercurous nitrate with chromate of potassium.
hese salts when heated, give off oxygen and mercury, and leave chromic oxide
eautiful green colour.

ROMATES OF MOLYBDENUM.—The neutral salt dissolves in water with yel-
lour, and yields by spontaneous evaporation, white, scaly, needle-shaped crystals.
cid salt dries up to an amorphous brown mass. The solution of either salt
with ammonia yields a precipitate of basic chromate of molybdenum.

ROMATE OF NICKEL.—Hydrate and carbonate of nickel dissolve in chromic
ith yellowish-red colour, forming an acid salt (Malaguti and Sarzeau). The

solution of a neutral nickel-salt boiled with neutral chromate of potassium, yields an amorphous precipitate, consisting of $3Ni^2O.2NiCrO^3 + aq.$, and having the colour of Spanish tobacco. If this or the soluble salt be covered with ammonia, a heavy yellow-green crystalline powder, $3NH^3.NiCrO^3 + \frac{2}{3}aq.$ is formed, which is decomposed by air and water.

Chromates of Potassium.—Three of these salts are known, viz.:

Neutral chromate, monochromate, or metachromate of potassium	$K^2O.CrO^3$, or K^2CrO^4
Acid or dichromate	$K^2O.2CrO^3$, or $K^2CrO^4.CrO^3$
Hyperacid or trichromate . . .	$K^2O.3CrO^3$, or $K^2CrO^4.2CrO^3$.

The neutral and acid salts are important articles of manufacture, being extensively used in dyeing and calico-printing, and for the preparation of chrome-yellow and chrome-red; also as oxidising agents: the acid salt is most used, because it contains a larger percentage of chromic acid.

The chromates of potassium are prepared by igniting chrome-iron ore, a compound of sesquioxide of chromium and protoxide of iron, in contact with alkalis and oxidising agents, and lixiviating the fused mass with water. A yellow solution is thus obtained, from which, by quick evaporation, the neutral salt is thrown down in yellow crystalline granules; and by redissolving this granular salt in water, and leaving the solution to evaporate slowly, the salt is obtained in regular crystals. The concentrated solution of the neutral chromate, treated with one of the stronger acids, yields the acid chromate; and by evaporating the solution to the crystallising point, picking out the crystals of acid chromate from the nitrate or other potassium-salt formed at the same time, and recrystallising several times, the acid chromate is obtained in large tabular crystals of an orange-red colour

The process first adopted for the preparation of chromate of potassium, was to calcine the ore with nitre; but it may be rendered more economical by substituting carbonate of potassium (pearlash) for a portion of the nitre; and still more by dispensing with the nitre altogether, and effecting the oxidation of the chromic oxide by means of air admitted into the reverberatory furnace in which the calcination takes place. But whether nitre be used or not, the oxidation is still found to be imperfect, because the alkali fuses into a thin liquid, and the chrome-iron ore, being very heavy, sinks to the bottom, and thus remains to a great extent unaltered, especially when the oxidation is effected by contact with the air, an inconvenience which is but imperfectly obviated even by continual stirring. But by adding lime to the mixture, as first proposed by Stromeyer, it is rendered less fluid, and a moderate amount of stirring then suffices to keep it well mixed, so that the oxidation takes place with much greater facility. It is found, indeed, that when lime is added, the nitre may be altogether dispensed with, and its place supplied by carbonate, sulphate, or chloride of potassium, which are cheaper. Mr. Tilghman has patented a process for the use of felspar as a source of alkali, 4 pts. by weight of that mineral being calcined in a reverberatory furnace, with 4 pts. of lime or an equivalent quantity of chalk, and 1 pt. of chrome-iron ore. Mr. Booth of Philadelphia subjects the chrome-iron ore to a preliminary ignition with coke or other carbonaceous material, whereby the iron is reduced to the metallic state, then removes the iron by means of dilute sulphuric acid, and subjects the chromic oxide thus purified, to calcination with alkali and nitre; by this means, the portion of oxygen which would be expended in converting the protoxide of iron into sesquioxide, is rendered available for the production of chromic acid. The production of sulphate of iron incidental to the process tends to defray the expense.

Jacquelain prepares acid chromate of calcium from chrome-iron ore, and converts that salt into acid chromate of potassium by double decomposition. The chrome-ore, after being ground to very fine powder and sifted, is mixed with chalk in rotating barrels, and the mixture is spread in a layer 1¼ to 2 inches thick on the hearth of a reverberatory furnace, heated to bright redness for nine or ten hours, and stirred at least every hour. After this treatment, the mixture has a yellowish-green colour, dissolves in hydrochloric acid, and with the exception of a certain quantity of sand, consists essentially of *neutral chromate of calcium* $Ca''CrO^4$ mixed with oxide of iron. This mass is ground to powder by millstones; the powder is stirred up with hot water, and sulphuric acid is added till a slight acid reaction becomes apparent. The neutral chromate of calcium is thereby converted into *acid chromate*. The liquid also contains sulphate of iron, which is precipitated in the same vessel by stirring up with chalk, which does not affect the chrome-salt. The precipitate having settled down, the clear solution of acid chromate of calcium containing a little sulphate is run off, and may be used, without further treatment, for preparing by double decomposition, acid chromate of potassium, chromate of lead, either neutral or basic, and chromate of

o obtain acid chromate of potassium, the solution of acid chromate of calcium
d with carbonate of potassium, which throws down carbonate of calcium in a
y to wash, leaving acid chromate of potassium in solution, which may then be
ed and crystallised. The chief advantages of this process are that it requires
ing than the ordinary method, even when lime is used, and that it avoids the
lkali, which always ensues (to the amount of 9 or 10 per cent.) when the mix-
hrome-iron ore and potassium-salt is raised to a bright red heat. (For further
on the manufacture of alkaline chromates, see *Ure's Dictionary of Arts,*
tures, and Mines, i. 684; and *Richardson* and *Watts' Chemical Technology*,
.)

tral Chromate of Potassium, $K''CrO^4$.—This salt is obtained by neutra-
e acid chromate with an alkali, or by igniting chrome-iron ore with excess of
. 936). It crystallises in double six-sided pyramids, belonging to the trimetric
and isomorphous with sulphate of potassium: hence it is capable of crystallising
latter in all proportions. It has a pale lemon-yellow colour, an alkaline re-
nd a cooling, persistently bitter taste: it is poisonous even in small doses.
gravity 2·705 (Kopp). 100 pts. of water at 15° C. dissolve $48\frac{1}{3}$ pts. of this
in boiling water it dissolves in all proportions. It possesses great colouring
pt. of it imparting a distinct yellow tint to 400,000 pts. of water, and a deep
olour to 20 pts. of nitre when crystallised therewith. It is insoluble in alcohol,
recipitated by alcohol from its aqueous solution. The solution yields by eva-
, red crystals of the acid chromate, and the alkaline mother-liquor after-
eposits yellow crystals of the neutral salt. The neutral chromate acquires a
t red colour when heated, melts at a higher temperature, and solidifies in the
ne form on cooling. It is not decomposed by simple ignition, but when heated
ss in contact with charcoal, sulphur, sal-ammoniac, and other reducing agents,
chromic oxide together with a potassium-salt. It is decomposed by acids,
carbonic acid, yielding the acid chromate of potassium. Sulphydric acid and
of potassium decompose it, with formation of chromic hydrate; sulphurous
ms at first brown oxide of chromium, then a chromic salt. According to
izer (J. pr. Chem. xxxix. 267), arsenious acid forms with it a gelatinous
ich after drying at 100° C. contains $4K^2O.3Cr^2O^3.3As^2O^3.10H^2O$.

id Chromate, $K^2O.2CrO^3 = K^2CrO^4.CrO^3$. *Bichromate of Potash, Red*
te of Potash.—This salt is obtained by treating the solution of the neutral salt
e of the stronger acids, or by precipitating a solution of acid chromate of
with carbonate of potassium (p. 936). It separates by rapid evaporation as
ge-coloured crystalline powder, and by slower evaporation in splendid garnet-
es or prisms, belonging to the triclinic system. It is permanent in the air,
litmus, has a cooling, bitter, and metallic taste. Its powerful oxidising pro-
ause it to exert a poisonous action on the animal economy, both internally and
ly: the workmen engaged in its manufacture suffer greatly from malignant
It dissolves in 10 pts. of water at 15° C., much more abundantly in boiling
it is insoluble in alcohol. It melts at a heat below redness to a transparent
d, which by slow cooling yields large fine crystals, having the same form as
tained from the aqueous solution, but crumbling to powder at lower tempera-
At a white heat, it gives off oxygen, leaving neutral chromate mixed with
oxide. Heated with charcoal, it is reduced, with slight detonation; paper or
turated with the solution and dried burns like tinder when heated. Paper
urated acquires a darker colour by exposure to light, but remains unaltered in
: hence it may be used in photography. Heated with strong sulphuric acid
off oxygen (about 16 per cent. by weight), and yields water and potassio-
sulphate (chrome-alum).

$$K^2Cr^2O^7 + 2H^2SO^4 = (Cr^2)^{vi}K^2(SO^4)^2 + 4H^2O + O^3.$$

reduced when heated with sulphur or sal-ammoniac. Sulphydric acid pre-
from its solution a mixture of chromic oxide and sulphur. Sulphurous acid
t green without forming a precipitate, from formation of chromic sulphate and
phate. A solution of the salt in boiling hydrochloric acid deposits on cooling
chloride of potassium (p. 938). The solution of acid chromate absorbs a con-
quantity of nitric oxide, acquiring a dark colour, and depositing after a while
xide of chromium.

centrated solution of the acid chromate mixed with strong sulphuric acid,
deep red precipitate of chromic acid.

ble salt, composed of *sulphate* and *acid chromate of potassium*, is obtained by
concentrated solution of the acid chromate with a quantity of sulphuric acid
n sufficient to convert the potassium into acid sulphate. It crystallises on
in stellate needles. (Reinsch.)

c. *Hyperacid Chromate, or Trichromate of Potassium*, $K^2O.3CrO^3$, or $K^2CrO^4.2CrO^3$, separates from a solution of the acid chromate in ordinary nitric acid prepared at 60° C., in dark red nacreous prisms, of specific gravity 3·631, which blacken when exposed to the air, and melt at 145°—150° C. (Graham.)

Chromate of Potassium and Ammonium, $K(NH^4)CrO^4$, crystallises from a concentrated solution of acid chromate of potassium saturated with ammonia, and cooled by a freezing mixture, or evaporated over lime, in crystals apparently isomorphous with sulphate of potassium: when exposed to the air it gives off ammonia and turns reddish-yellow. (Johnson, J. pr. Chem. lxii. 261.)

Chromate of Potassium with Mercuric Chloride, $K^2CrO^4.2Hg''Cl^2$, is obtained by mixing the component salts in equivalent proportions, and adding sufficient hydrochloric acid to redissolve the precipitate first produced. Small slightly reddish crystals, which form a yellow solution in water. Another salt, $K^2CrO^4.CrO^3.HgCl^2$, is obtained in red spicular crystals, by mixing acid chromate of potassium and mercuric chloride in equivalent proportions, and leaving the solution to evaporate. (Darby, Chem. Soc. Qu. J. i. 24.)

Chromate of Potassium with Mercuric Cyanide, $K^2CrO^4.3HgCy^2$.—Light yellow laminar crystals, obtained by evaporating a solution of 1 pt. neutral chromate of potassium and 3 pts. cyanide of mercury. (Darby.)

Chromo-chloride of Potassium, $KCl.CrO^3 = \left.\begin{matrix}(CrO^2)''\\K\end{matrix}\right\}\begin{matrix}O\\Cl\end{matrix}$. This salt, which is analogous in composition to the triacid chromate $K^2CrO^4.2CrO^3$, is obtained by dissolving together, with aid of heat, 3 pts. acid chromate of potassium, and 4 pts. hydrochloric acid, avoiding evolution of chlorine. It crystallises in flat, red, rectangular prisms, and is decomposed by solution in water.

Chromates of Silver.—The *neutral salt*, Ag^2CrO^4, is obtained as a red precipitate by decomposing neutral chromate of potassium with nitrate of silver, or by boiling the acid silver-salt with water, whereby it is partly resolved into chromic acid and the neutral chromate, which then separates in crystals green by transmitted light, and yielding a red powder. A solution of the acid salt in ammonia deposits the neutral salt on evaporation, in dark green metallic crusts.

Acid Chromate of Silver, $Ag^2CrO^4.CrO^3$, is obtained by immersing metallic silver in solution of acid chromate of potassium mixed with sulphuric acid, or by precipitating the same acidulated solution with a silver-salt. It has the colour of carmine, is partly soluble in water, and crystallises therefrom in triclinic prisms, having a dark brown colour, red by transmitted light, and yielding a red colour.

Ammonio-chromate of Silver, $4NH^3.Ag^2CrO^4$, separates from a hot solution of chromate of silver in ammonia, in yellow, square prisms, isomorphous with the corresponding salts of sulphuric and selenic acid; they give off ammonia when exposed to the air.

Chromates of Sodium.—Two of these salts are known, namely, the *neutral chromate*, Na^2CrO^4, and the *acid chromate*, $Na^2CrO^4.CrO^3$. They are analogous in all respects to the neutral and acid chromates of potassium, and may be prepared in like manner. The neutral salt, which may also, according to Johnson (J. pr. Chem. lxii. 161), be obtained by saturating a solution of acid chromate of potassium with carbonate of sodium, and leaving it to evaporate at 0° C., crystallises at low temperatures in yellow transparent crystals, containing $Na^2CrO^4.10aq.$, isomorphous with Glauber salt: they melt at the heat of the hand, deliquesce rapidly in the air, are easily soluble in water, sparingly in alcohol, and when immersed in alcohol, become opaque from loss of water. The aqueous solution evaporated at temperatures above 30° C., deposits the anhydrous salt.

Acid chromate of sodium, $Na^2CrO^4.CrO^3$, forms thin, hyacinth-red prisms, very soluble in water.

Chromate of Strontium.—Light yellow powder, obtained by precipitation; soluble in hydrochloric, nitric, and chromic acid; rather more soluble in water than the barium-salt.

Chromates of Tin.—Stannic chloride forms with chromate of potassium a yellow precipitate, which becomes brownish-yellow and translucent when dry, and passes into violet stannic chromate when ignited.

Stannous chromate is precipitated in yellow curdy flocks, when stannous chloride is added with stirring to excess of chromate of potassium. If the contrary course be adopted, a greenish-white precipitate is formed, perhaps consisting of chromic stannate. The salt leaves a violet residue when ignited.

Uranic Chromate.—Uranic nitrate forms an ochre-yellow precipitate with neutral chromate of potassium. The yellow rough-tasting solution of uranic carbonate in aqueous chromic acid, yields small fiery-red crystals. The salt melts at a gentle heat, with partial decomposition.

romate of Vanadium.—The brownish-yellow solution of vanadic hydrate eous chromic acid, yields on evaporation, a shining, dark brown, varnish-like which dissolves partially in water, forming a yellow liquid.

romate of Yttrium.—Soluble salt, crystallising in small yellow prisms.

romate of Zinc.—Sulphate of zinc, mixed with neutral chromate of potas- forms a yellow precipitate of a basic salt. Malaguti and Sarzeau, by treating ate of zinc with pure chromic acid, obtained a yellow crystalline basic salt, con- $4ZnO.CrO^3 + 5aq.$, or $Zn^3CrO^6.ZnH^2O^2 + 4aq.$ By boiling this salt with c acid as long as anything dissolves, the same chemists obtained a soluble non- line salt, $2Zn''O.3CrO^3$, or $2ZnCrO^4.CrO^3$.

monio-chromate of Zinc.—The tetrabasic salt repeatedly treated with am- yields yellow cubic crystals, containing $ZnCrO^4.NH^3 + 5aq.$ Soluble chromate , $2ZnO.CrO^3$, treated with excess of ammonia and then with alcohol, yields a precipitate, consisting of microscopic needles containing $5NH^3.2ZnCrO^4 + 9aq$ guti and Sarzeau.)

omate of Zinc and Potassium.—The precipitate formed by chromate of um in sulphate of zinc, if left for some time under the liquid, changes to an orange- powder, consisting of the double salt. It is sparingly soluble in cold water, but s a yellow colour to a large quantity of the liquid; in boiling water, it dissolves ep yellow colour, with separation of a lighter coloured basic salt. When ignited, s a dark brown residue, from which water extracts neutral chromate of potassium, a compound of sesquioxide of chromium and oxide of zinc. (Handw. d. Chem. 1246.)

ROME ALUM. This name is applied to the double sulphates of chromium e alkali-metals, analogous in composition to common alum and isomorphous th, *e.g. potassio-chromic sulphate*, $K^2(Cr^2)^{vi}(SO^4)^4 + 24H^2O$ or $\left.\begin{matrix}(S^2O^4)^{iv}\\K.(Cr)'''\end{matrix}\right\}O^4$ +

ROME GREEN. A name applied sometimes to green oxide of chromium, nes to the pigment produced by mixing chrome yellow with Prussian blue. ROMATE OF LEAD, p. 934.)

ROME IRON ORE. *Chromic Iron, Chromate of Iron, Chromeisenstein, rom, Ferrochromate.*—This mineral, which is the most abundant ore of chromium, occurs massive, with fine granular or compact structure, forming veins or im- masses in serpentine; more rarely in regular octahedrons, with imperfect e parallel to the octahedral faces. Specific gravity 4·32 to 4·57. Hardness 5·5. brownish-black, or iron-black. Streak brown. Lustre submetallic, inclining . Opaque. Brittle, with conchoïdal or uneven fracture. Sometimes magnetic. the blowpipe it does not fuse, but becomes more strongly magnetic. With r phosphorus-salt it fuses with difficulty, but completely, to a beautiful green .

me iron ore belongs to the spinel group of minerals, whose general formula is O^3 or $\left.\begin{matrix}M''\\(R^2)^{vi}\end{matrix}\right\}O^4$. The bivalent metal is chiefly iron, but magnesium is y also present in considerable quantity, and in some specimens a small portion chromium appears to exist as chromosum. The trivalent metal R is prin- chromium, but it is replaced to a considerable extent by aluminium, and es also by iron (ferricum), so that the general formula of the mineral is $\left.\begin{matrix}Ig;\ Cr)''\\l^2;\ Fe^2)^{vi}\end{matrix}\right\}O^4$. From the numerous analyses that have been made of it, we e following as samples of the different varieties: *a*, from Baltimore, Maryland, ch (Pogg. Ann. xxxiii. 335); *b*, from Volterra, Tuscany, by Bechi (Sill. Am. iv. 62); *c*, from Texas, Lancaster county, Pennsylvania, by Franke (*Ram- y's Mineralchemie*); *d*, from the same, by Garrett (Sill. Am. J. [2] xiv. 46); allised, from Baltimore, by Abich (*loc. cit.*); *f*, from Beresow, Siberia, by g (J. pr. Chem. xliii. 119):

	a	*b*	*c*	*d*	*e*	*f*
Cr^2O^3 . .	55·37	44·23	55·14	63·38	58·25	59·80
$Cr''O$ . .	—	—	—	—	1·61	4·39
Fe^2O^3 . .	1·10	0·33	12·06	—	—	—
$Fe''O$ . .	18·04	35·32	18·02	38·66	20·13	18·59
Al^2O^3 . .	13·97	20·83	5·75	—	11·85	10·93
$Mg''O$ . .	10·04	—	9·39	—	7·45	6·74
$Ni''O$ . .	—	—	—	2·28	—	—
	98·52	100·71	100·36	104·32	99·29	100·45

Besides the above localities, chrome-iron ore is found in the islands of Unst and Fetlar in the Shetland group, in the Département du Var in France, in Silesia and Bohemia, at Röraas in Norway, near Kraubat in Syria, abundantly in Asia Minor and the Eastern Urals, and in several parts of North America. It assists in giving the green colour to verd-antique marble. The ore used in this country is obtained chiefly from the Shetland Isles, Norway, and Baltimore, the quantity amounting to 2000 tons annually. (Dana, ii. 106; *Rammelsberg's Mineralchemie*, p. 172.)

CHROME-MICA. This name was given by Breithaupt to an emerald-green mica with nacreous lustre from the Pinzgau.

CHROME-OCHRE. Native chromic oxide.

CHROME-RED and **CHROME-YELLOW.** See Chromates of Lead (p. 934).

CHROMIC ACID. (pp. 931, 952).—**CHROMITE.** Syn. with Chrome-Iron Ore

CHROMITES. Compounds of sesquioxide of chromium with protoxides (p. 951).

CHROMIUM. *Symbol* Cr. *Atomic weight* 52·2.—This metal was discovered by Vauquelin in 1797. It is not very abundant, and never occurs in the free state. It is found as sesquioxide (*chrome-ochre*), as sesquioxide combined with protoxide of iron (*chrome-iron ore*), as chromate of lead (*crocoisite* or *red lead-spar*, p. 934); in small quantity in many iron ores, and frequently in meteoric iron; it is also the colouring principle of many minerals, as the emerald, green serpentine, olivin, &c.

The most abundant ore of chromium is chrome-iron. This mineral ignited with alkalis in presence of oxidising agents, yields a chromate of the alkali-metal; these salts treated with acids and reducing agents yield sesquioxide of chromium; and from this substance the metal itself, and many of its compounds, may be prepared.

Metallic chromium is obtained by reduction of the oxides or chlorides, as when sesquioxide of chromium is mixed with one-third of its weight of lamp-black or sugar-charcoal and exposed in a crucible lined with charcoal to the heat of a blast furnace; the metal is thereby obtained as a whitish-grey mass, which cannot be melted together into a button. Péligot, by heating the violet sesquichloride of chromium with potassium, obtained the metal in the form of a dark grey powder. Frémy, by heating the sesquichloride in a porcelain tube and passing vapour of sodium over it in a current of hydrogen, obtained it in very hard shining crystals. Bunsen, by electrolysing a solution of the sesquioxide, obtained the metal in brittle laminæ, having the colour of iron and metallic lustre. According to Berzelius, when sesquichloride of chromium is heated in an atmosphere of hydrogen, there is obtained, besides the protochloride, a shining deposit of metallic chromium.

Wöhler (Ann. Ch. Pharm. cxi. 230) obtains metallic chromium by reducing the sesquichloride with zinc. One pt. of the violet sesquichloride, and 2 pts. of a mixture of the chlorides of potassium and sodium (7 pts. chloride of sodium to 9 pts. chloride of potassium) are closely pressed into an ordinary earthen crucible, 2 pts. of zinc are laid on the mixture, and the whole is covered with a layer of the flux. The crucible is then gradually heated to redness, and the mass is kept in a state of fusion, till a hissing noise is heard, and a zinc-flame is observed on removing the cover for a moment. The crucible is then taken out, gently tapped to cause the metal to collect, and left to cool. A good regulus of zinc is then found at the bottom covered with a green slag. This regulus is well washed with water and digested in dilute nitric acid, which dissolves the zinc, and leaves the chromium in the form of a grey powder, which must be purified by again heating it with nitric acid and washing. By this method Wöhler obtained 6 or 7 grms. of metal from 30 grms. of the chloride, the calculated quantity being 10 grms. Magnesium may be used in the reduction instead of zinc, but it offers no particular advantage. With cadmium as the reducing agent, a violent explosion occurred.

Chromium obtained by Wöhler's process is a light green, glistening, crystalline powder, which, when magnified fifty times, exhibits aggregates of crystals like fir-branches, interspersed with individual crystals of tin-white colour, high lustre, and specific gravity 6·81 according to Wöhler, 7·3 according to Bunsen. These crystals, according to Wöhler, have the form of a very acute rhombohedron; but according to Bolley (Chem. Soc. Qu. J. xiii. 334), who examined them with a magnifying power of 85, they are quadratic octahedrons with acuminated summits and bevelled terminal edges, and very frequently united by fours in the form of a cross. This is the third example known of an elementary body crystallising in the dimetric or quadratic system, the others being tin and boron; as a general rule, ductile metals crystallise in the monometric or regular system; brittle metals in the hexagonal system.

Wöhler's chromium does not exert the slightest action on the magnetic needle. When heated to redness in the air, it acquires a yellow and blue tarnish like steel, and gradually becomes covered with a thin film of green oxide; but the oxidation is by no means complete. Thrown into a spirit flame fed with oxygen, it burns with sparkling,

so brightly as iron. On melting chlorate of potassium it burns with dazzling
ght. Melting nitre oxidises it very readily, but without incandescence. In
carbonate of sodium it remains unaltered. Heated in chlorine gas, it exhibits
candescence. It is but superficially converted into green oxide by ignition in
n of aqueous vapour free from air. Hydrochloric acid dissolves it readily, with
on of hydrogen, forming blue chromous chloride. Dilute sulphuric acid does not
n it at ordinary temperatures, but on applying a gentle heat, a violent action
y takes place, and the remaining metal acquires the power of dissolving easily
nost dilute sulphuric acid, even after washing. It is not attacked by nitric
ther concentrated or dilute. (Wöhler.)

properties of chromium differ considerably, according to the manner in which
pared, the peculiarity doubtless depending chiefly on the state of aggregation.
s chromium oxidised with great facility, taking fire in the air, even at a heat
edness, and being converted into green sesquioxide. It likewise dissolved in
ulphuric and hydrochloric acids, and was oxidised by nitric acid.

crystals of chromium obtained by Frémy belong, according to Sénarmont, to the
system. They were not attacked by any acid, not even by nitromuriatic acid.
mium may be polished, and then acquires a fine metallic lustre. When pure it
less fusible than platinum (Deville, Polyt. Centralbl. 1857, p. 605). A frag-
f it scratches glass; it is at least as hard as corundum.

mium unites with *bromine*, *chlorine*, *fluorine*, *iodine*, *cyanogen*, *nitrogen*, *oxygen*,
orus, and *sulphur*, also with *aluminium* and *iron*. There are two classes of
um-compounds, into which the chromium enters as the positive or basic ele-
amely, the chromous compounds, in which it is bivalent, *e.g.* $Cr''Cl^2$, $Cr''O$,
&c., and the chromic compounds, in which it is trivalent, *e.g.* Cr^2Cl^6, Cr^2O^3,
$)^3$, &c. It likewise forms an oxide or anhydride, CrO^3, in which it is sex-
and to this there corresponds a class of salts, the chromates, into which the
m likewise enters as a triatomic radicle, *e.g.* chromate of lead, $\left.\begin{matrix}Cr^{vi}\\Pb''\end{matrix}\right\}O^4$.

OMIUM, BROMIDES OF. The *anhydrous tribromide*, Cr^2Br^6, may be
d, like the chloride, by passing bromine-vapour over an ignited mixture of
oxide with charcoal and starch-paste. Part of the resulting bromide then
s beyond the mass of oxide, while another portion remains therein in crystal-
les, which, however, are easy to separate. It forms black semi-metallic hexa-
cales, translucent with olive-green colour, and exhibiting in one direction a
d dichroism. It forms a yellowish-green powder when triturated, in which
so part of the compound sublimes during the preparation. It is quite insoluble
ure, but dissolves to a green liquid if mixed with protobromide. It is decomposed
lis more easily than the chloride. When gently heated in hydrogen gas, it is
to the white dibromide, $CrBr^2$, which on exposure to the air quickly de-
s to green oxybromide. (Wöhler, Ann. Ch. Pharm. cxi. 382.)

ution of chromic bromide is obtained by dissolving chromic hydrate in hydro-
acid, or by treating chromate of silver with hydrobromic acid and alcohol.
ution yields green crystals, and is easily decomposed by evaporation, with
on of oxybromide.

OMIUM, CHLORIDES OF. Two chlorides of chromium are known in
state, viz. $CrCl^2$ and Cr^2Cl^6. A hexchloride, $CrCl^6$, may also be supposed to
ombined with chromic anhydride, in chlorochromic anhydride, $CrCl^6.CrO^3$.

ILORIDE OF CHROMIUM or CHROMOUS CHLORIDE. $CrCl^2$. (Moberg,
hem. xxix. 175; Péligot, Ann. Ch. Phys. [3] xii. 527.)—This compound is
l by passing hydrogen gas over perfectly anhydrous trichloride of chromium
tly heated, as long as hydrochloric acid gas continues to escape. The hydrogen
previously freed from all traces of oxygen by passing it through a solution
nous chloride in caustic potash, then through tubes containing sulphuric acid
oride of calcium, and last over red-hot metallic copper. The dichloride is
med by passing dry chlorine gas over a red-hot mixture of charcoal and chromic
The first method yields the dichloride in the form of a white, velvety sub-
retaining the form of the trichloride from which it has been formed; the
method yields it in fine white crystals, usually mixed, however, with chromic
hromic chloride, and charcoal.

oride of chromium dissolves in water, with evolution of heat, forming a blue
, which rapidly turns green when exposed to the air or to chlorine gas. With
it forms a dark brown precipitate (yellow, according to Moberg, if the air be com-
excluded) of hydrated chromous oxide, which, however, quickly changes to light
chromosochromic oxide, with evolution of hydrogen. *Ammonia* forms a sky-
ecipitate, which turns green on exposure to the air. With ammonia and sal-
iac, a blue liquid is formed, which turns red on exposure to the air. *Sulphide*

of ammonium or *potassium* forms a black precipitate of chromous sulphide. The solution of dichloride of chromium is one of the most powerful deoxidising agents known. With a solution of *neutral chromate of potassium*, it forms a dark brown precipitate of chromosochromic oxide, which, however, disappears on the addition of an excess of the dichloride, and forms a green solution. It precipitates *calomel* from a solution of corrosive sublimate. With *cupric salts*, it forms at first a white precipitate of cuprous chloride, but when added in excess, throws down red cuprous oxide. It instantly converts *tungstic acid* into blue oxide of tungsten, and precipitates *gold* from the solution of the chloride.

A solution of chromous chloride, containing zinc, may be obtained, according to Loewel (J. pr. Chem. lxii. 11), by pouring a solution of the trichloride, or of chrome-alum, in 3 to 5 pts. water, made as neutral as possible, into a bottle nearly filled with granulated zinc. Hydrogen is then evolved for some hours, and a fine blue liquid is formed, which, if left to stand in contact with the zinc, continues slowly to evolve hydrogen and deposit a light grey chromous oxychloride, and after four or six months becomes perfectly colourless.

TRICHLORIDE OF CHROMIUM. Chromic Chloride. Cr^2Cl^6.—The anhydrous trichloride is prepared by igniting an intimate mixture of chromic oxide and charcoal in a stream of dry chlorine gas. A mixture of the oxide with lamp-black is made up into pellets with starch; these are well baked in a covered crucible, and then introduced into another crucible, through the bottom of which there passes a porcelain tube connected with an apparatus for evolving chlorine. Into the mouth of this crucible is fitted a smaller one, placed in an inverted position. The lower crucible stands on the grate of an ordinary air-furnace, and as soon as the apparatus is filled with dry chlorine, the mixture is heated to bright redness, the firing being so regulated as to keep the upper crucible comparatively cool, so that the chloride as it is produced may sublime into it. When the process is completed, the stream of chlorine must be kept up till the apparatus is cool, to prevent the formation of sesquioxide or protochloride. The trichloride is then washed with water to free it from chloride of aluminium derived from the crucible. If it contains dichloride, which is the case if the stream of chlorine has not been strong enough, it will dissolve during washing (Wöhler, Pogg. Ann. xi. 148). The trichloride may also be obtained by heating the sesquisulphide in a stream of dry chlorine. (Berzelius.)

Anhydrous chromic chloride forms shining micaceous laminæ of a beautiful peach-blossom colour, which may be rubbed on the skin like talc. It is quite insoluble in cold water; but, if boiled in the finely divided state with water, it slowly dissolves and forms a green solution. If the cold water contains in solution a small quantity of chromous chloride, not even exceeding $\frac{1}{4000}$ to $\frac{1}{1000}$, the trichloride dissolves immediately, with evolution of heat, forming a green solution identical with that obtained by dissolving chromic hydrate in hydrochloric acid. The effect is perhaps due to the formation of an intermediate chloride, which is immediately resolved by the action of water into dichloride and the soluble green modification of the trichloride, the dichloride thus liberated again acting in the same manner (see p. 943). The addition of a small quantity of stannous or cuprous chloride is said to produce the same effect.

Anhydrous chromic chloride is not decomposed by sulphuric acid, either strong or dilute, or by hydrochloric, nitric, or nitromuriatic acid, or by ammonia, carbonate of potassium, or carbonate of sodium: *caustic potash* attacks it but slightly at the boiling heat. Fused with *nitre* and an *alkali* or *alkaline carbonate*, it yields a chromate and chloride of the alkali-metal. *Potassium*, *zinc*, &c., separate metallic chromium from it. Heated in a stream of *hydrogen*, it yields chromous chloride, and if the heat be strong, metallic chromium is likewise separated. Heated to redness in the *air*, it gives off chlorine and yields green chromic oxide. By ignition in *phosphoretted hydrogen gas*, it is converted into phosphide of chromium. Heated with *sulphur*, or in a stream of *sulphydric acid gas*, it yields sulphide of chromium. Ignited in *ammonia gas*, it forms nitride of chromium.

By dissolving chromic oxide in hydrochloric acid, or by boiling chromate of lead or silver with hydrochloric acid and alcohol, or even with excess of hydrochloric acid alone, a green solution is obtained, containing the modification of chromic chloride which corresponds to the green chromic oxy-salts (p. 950). This solution, when evaporated, yields a non-crystalline dark green syrup, which, when heated to 100° C. in a stream of dry air, yields a green mass containing $Cr^2Cl^6.9H^2O$ (Moberg, J. pr. Chem. xxix. 175). The same solution evaporated in vacuo yields green granular crystals containing $Cr^2Cl^6.2H^2O$. (Péligot, *ibid.* xxxvii. 475.)

Hydrated chromic chloride heated to 250° C. in a stream of hydrochloric acid or chlorine gas, gives off its water and yields delicate peachblossom-coloured scales, which are soluble in water and even deliquescent; but, if more strongly heated in either of

ses, it begins to sublime, and the sublimed chloride thus obtained is insoluble
, like that obtained by igniting chromic oxide with charcoal in a stream of
The anhydrous chloride cannot be obtained by heating the hydrated chloride
air: for hydrochloric acid is then given off and soluble oxychloride produced,
ds an insoluble oxychloride, and the residue ultimately consists of green
oxide. In this respect, the hydrated trichloride of chromium resembles the
nding compounds of iron and aluminium.

e of silver added to a green solution of chromic chloride, throws down at first
f the chlorine; but on leaving the liquid to stand, or on boiling it, the whole
lorine is precipitated. This effect was attributed by Berzelius to the tendency
ic chloride to form double salts; by Otto to the solubility of chloride of silver
ic nitrate.

ition of chromic chloride, corresponding to the violet solutions of the chromic
oxygen-acids, may be obtained by precipitating one of these violet salts by an
nd dissolving the precipitated hydrate in hydrochloric acid; also by decom-
he violet sulphate with chloride of barium. From these solutions nitrate of
nmediately throws down all the chlorine. If, however, the violet solution of
ride be boiled, it turns green, and after this change the chlorine is but partially
ated by nitrate of silver.

ic chloride unites with the chlorides of the more basic metals, forming salts
g $2MCl.Cr^2Cl^6$, or $M^2Cr^2Cl^6$, of which however only the potassium, sodium, and
um-compounds have been investigated. They are obtained by mixing the cor-
ng acid chromates with excess of hydrochloric acid and alcohol, and evaporating
water-bath till the mass turns violet. The double chlorides thus obtained
green and deliquesce on exposure to the air. Treated with a small quantity
water, they dissolve, with deep yellowish-red colour, which in a short time
nto pure chrome-green. If the solution be then left to evaporate, the alkaline
separates out, and the chromic chloride remains in the form of a green syrup.
ouble chlorides belong therefore to the violet modifications of chromic salts, but
omposed by water into chloride of alkali-metal and green chromic chloride,
oes not form double chlorides. The effect of chromous, stannous, and cuprous
s in facilitating the solution of anhydrous chromic chloride in water (p. 942)
y depends upon the formation of analogous double chlorides. If the double
decomposed by slow evaporation be mixed with hydrochloric acid and evapo-
dryness over the water-bath, the double chloride is reproduced. When the dry
chlorides are treated with absolute alcohol, green chromic chloride dissolves,
ose-coloured salt remains, consisting, according to Berzelius, of $6MCl.Cr^2Cl^6$.

OMIUM, DETECTION AND ESTIMATION OF. 1. All compounds
nium ignited with a mixture of *nitre* and an *alkaline carbonate* yield a chromate
alkali-metal, which may be dissolved out by water, and on being neutralised
etic acid, will give the characteristic precipitates of chromic acid with lead and
lts.

oxides of chromium and their salts, fused with *borax* in either blowpipe flame,
n emerald-green glass. The same character is exhibited by those salts of
acid whose bases do not of themselves impart decided colours to the bead.
duction of the green bead in both flames distinguishes chromium from ura-
nd vanadium, which give green beads in the inner flame only.

actions in Solution.—The chromic salts exhibit two principal modifications,
n and the violet. *Ammonia* produces in solutions of the green salts, a greyish-
recipitate; in solutions of the violet salts, a greyish-blue precipitate, both
however yield green solutions with sulphuric or hydrochloric acid. The
bove the precipitate has a reddish colour, and contains a small quantity
mic acid. *Potash* and *soda* form similar precipitates, which dissolve in
f the alkali, forming green solutions from which the chromic oxide is
ted by boiling. The *alkaline carbonates* form greenish precipitates (violet
e-light) which dissolve to a considerable extent in excess of the reagent.
ric acid forms no precipitate; *sulphide of ammonium* throws down the
l sesquioxide.

immersed in a solution of chrome-alum or trichloride of chromium, excluded
e air, gradually reduces the chromic salt to a chromous salt, the liquid after a
rs acquiring a fine blue colour, and hydrogen being evolved by decomposition
. If the zinc be left in the liquid after the change of colour from green to blue
ete, hydrogen continues to escape slowly, and the liquid, after some weeks or
is found no longer to contain chromium, the whole of that metal being pre-
d in the form of a basic salt, and its place taken by zinc. *Tin*, at a boiling
ewise reduces the chromic salt to a chromous salt, but only to a limited extent;

and on leaving the liquid to cool after the action has ceased, a contrary action takes place, the dichloride of chromium decomposing the dichloride of tin previously formed, reducing the tin to the metallic state, and being itself reconverted into sesquichloride. *Iron* does not reduce chromic salts to chromous salts, but merely precipitates a basic sulphate of chromic oxide, or an oxychloride, as the case may be.

Chromous salts are but rarely met with in solution: for their characters, see DICHLORIDE OF CHROMIUM (p. 942).

Chromic acid and its salts are recognised in solution by forming a pale yellow precipitate with *barium*-salts, bright yellow with *lead*-salts, brick red with *mercurous*-salts, and crimson with *silver*-salts (p. 932).

3. *Quantitative Estimation.*—Chromium is usually estimated in the state of sesquioxide. When it exists in solution as a chromic salt, it may be precipitated by ammonia, care being taken to avoid a large excess of that reagent (which would dissolve a portion), and to heat the liquid for some time. The chromic oxide is then completely precipitated, and the precipitate, after washing and drying, is reduced by ignition to the state of anhydrous sesquioxide, containing 69·1 per cent. of the metal.

When chromium exists in solution in the state of chromic acid, it is best to precipitate it by a solution of mercurous nitrate; the mercurous chromate thereby thrown down yields by ignition the anhydrous sesquioxide. The chromic acid might also be precipitated and estimated in the form of a barium or lead-salt.

Chromic acid may also be estimated by means of oxalic acid, which reduces it to sesquioxide, being itself converted into carbonic acid. The quantity of carbonic anhydride evolved determines the quantity of anhydrous chromic acid present, 3 at. CO^2 corresponding to 1 at. Cr^2O^3, as shown by the equation:

$$2CrO^3 + 3C^2H^2O^4 = Cr^2O^3 + 6CO^2 + 3H^2O.$$

The mixture may be heated in the carbonic acid flask represented in *fig. 5*, p. 119. If the object be merely to determine the quantity of chromium present, any salt of oxalic acid may be used; but if the alkalis are also to be estimated in the remaining liquid, the ammonium or barium-salt must be used.

Lastly, chromic acid may be estimated by Bunsen's volumetric method. The chromic acid is decomposed by boiling with excess of hydrochloric acid, whereupon 1 at. chromic anhydride eliminates 3 at. chlorine:

$$2CrO^3 + 12HCl = Cr^2Cl^6 + 6H^2O + 3Cl^2;$$

and the 3 at. chlorine passed into a solution of iodide of potassium, liberate 3 at. iodine, which is estimated by a standard solution of sulphurous acid, as described under VOLUMETRIC ANALYSIS (p. 264), so that 3 at. iodine correspond to 1 at. CrO^3.

4. *Separation of Chromium from other Elements.*—Chromic oxide, in the state of neutral or acid solution, is easily separated from the *alkalis* or *alkaline earths* by precipitation with ammonia, care being taken in the latter case to protect the liquid and precipitate from the air. The same method, with addition of sal-ammoniac, serves to separate chromic oxide from *magnesia*. The separation from the alkaline earths and from magnesia may also be effected by precipitating the whole with an alkaline carbonate, and igniting the precipitate with a mixture of carbonate of sodium and nitre. The chromium is then converted into chromate of sodium, which may be dissolved out, and the solution, after neutralisation with nitric or acetic acid, treated with mercurous nitrate as above.

From *alumina* and *glucina*, chromic oxide may be separated by treating the solution with excess of potash, and boiling the liquid to precipitate the chromic oxide. The separation is, however, more completely effected by fusing with nitre and carbonate of sodium, treating the fused mass with water, adding an excess of nitric acid to dissolve anything that may be insoluble in water, and precipitating the alumina or glucina by ammonia.

Another method of converting chromic oxide into chromic acid, and thereby effecting its separation from the above-mentioned oxides, is to treat the mixture with excess of potash, and heat the solution gently with peroxide of lead. The whole of the chromium is then converted into chromic acid, and remains dissolved as chromate of lead in the alkaline liquid; and on filtering from the excess of peroxide of lead, and any other insoluble matter that may be present, and supersaturating the filtrate with acetic acid, the chromate of lead is precipitated. (Chancel, Compt. rend. xliii. 927.)

Chromic acid may be separated from the *alkalis* in neutral solutions by precipitation with mercurous nitrate; also by reducing it to chromic oxide with hydrochloric acid and alcohol, and precipitating by ammonia. From the *earths* it may also be separated by this latter method, or, again, by fusing with carbonate of sodium, dissolving out with water, &c.

From *iron*, *zinc*, *nickel*, *cobalt*, *uranium*, and *cerium*, chromium may be separated by

h nitre and carbonate of sodium, or with the carbonate alone if it is already in
f chromic acid. Or, again, the separation may be effected by means of potash
ide of lead, according to Chancel's method above described.

aration of chromium from *manganese* cannot be effected immediately in this
ecause the manganese is at the same time converted into manganate or per-
e of sodium; but on dissolving in water and adding alcohol to the solution,
nese is reduced to peroxide and completely precipitated, while the chromium
issolved as chromate.

tanium, *tantalum*, and *columbium*, chromium, if in the state of sesquioxide,
parated by fusing the mixture with nitre and alkaline carbonate, extracting
r, reducing the chromium to the state of sesquioxide by boiling with hydro-
id, and precipitating by ammonia.

opper, *lead*, *tin*, and the other metals of the first group (p. 217), chromium
ed by sulphydric acid.

mate chromic acid in presence of *sulphuric acid*, the chromium is first re-
sesquioxide as above; the sulphuric acid is then precipitated, after conside-
tion, by chloride of barium; the excess of barium is removed by sulphuric
l the chromic oxide precipitated by ammonia.

phosphoric acid is present in solution, together with chromic acid, the phos-
id is precipitated as phosphate of magnesium and ammonium, and then the
cid by any of the preceding methods.

hloric acid is separated from chromic acid by nitrate of silver, and the excess
is removed by sulphuretted hydrogen, the chromic acid being at the same
uced to sesquioxide, which may be precipitated by ammonia.

acid is separated from chromic acid in the same manner as from all other
s, and the chromium is afterwards precipitated as oxide.

sesquioxide of chromium and chromic acid occur together in solution, the
acid may be precipitated by mercurous nitrate, the solution being first com-
eutralised, and the sesquioxide precipitated from the filtrate by ammonia,
the same time throws down a mercury-compound, to be afterwards separated
chromic acid by ignition.

tion of Chrome-ores.—The value of a chrome-ore depends upon the
of chromic acid that it will yield. To ascertain this point, the ore is calcined
ixture of nitre, alkali, and lime, the use of the lime being to keep the mixture
y condition, and prevent the heavy ore from falling to the bottom (see p. 936),
ch the soluble chromate is extracted, and the amount of chromic acid may
letermined by any of the methods already given.

sor Calvert of Manchester, has given two processes for the valuation of chrome
hem. Soc. Qu. J. v. 194.)

ore in fine powder is mixed with three or four times its weight of soda-lime
l by slaking quick lime with caustic soda, then drying and calcining the mass),
is mixture of soda-lime and ore is added one-fourth of nitrate of sodium. The
then well calcined for two hours, care being taken to stir the pasty mass
arter of an hour with a platinum wire. This mixture not becoming fluid, the
nstantly kept in contact with the oxygen of the atmosphere, and thus the oxide
ium is converted into chromic acid. One treatment is generally sufficient for
lete decomposition of the ore.

reater part of the mass is now dissolved in water, and the insoluble portion
ith sulphuric acid diluted with twice its bulk of water; the whole is then re-
om the crucible, and a little alcohol is added to the solution in order to render
ate of calcium insoluble. The whole is next thrown on a filter and washed with
ohol, which dissolves all the acid chromate formed, and leaves the sulphate of
together with any portion of ore that may not have been attacked. The sul-
calcium may be removed by washing the filter with boiling water, and the
ore, if any, is to be recalcined.

olution containing the acid chromate of sodium is now neutralised with
, and oxalate of ammonium is added, which gives rise to a small precipitate of
de of iron, alumina, and oxalate of calcium, together with a little silica dis-
y the sulphuric acid. The precipitate having been separated and well washed,
r is either mixed with alcohol to reduce the chromic acid to the state of ses-
which may then be precipitated, washed, dried, ignited, and weighed; or,
he liquor is rendered acid, and the amount of chromic acid estimated by
process (Chem. Soc. Qu. J. iv. 239) with dichloride* of tin (commonly called
ride). This method depends on the reaction of dichloride of tin with acid
of sodium or potassium in presence of free hydrochloric acid, whereby

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* Atomic weight of tin = 118.

the dichloride of tin is converted into tetrachloride, and the chromic acid into sesquichloride of chromium:

$$3SnCl^2 + Na^2CrO^4.CrO^3 + 14HCl = 3SnCl^4 + 2NaCl + 7H^2O + Cr^2Cl^6.$$

A solution of dichloride of tin of known strength* is added to the solution of acid chromate of sodium, till the latter is completely decomposed,—which may be known by the solution no longer giving a yellow precipitate with acetate of lead—and the quantity of acid chromate present is calculated from the amount of tin in the solution used. Penny has shown, by direct experiment, that in the above reaction, 100 pts. of metallic tin correspond to 83·2 pts. of acid chromate of potassium, or 78·4 pts. of acid chromate of sodium.

b. The finely divided ore is calcined with nitrate of barium, a small quantity of caustic potash being added towards the end of the operation to facilitate the action, and give rise to chromate of potassium. The pasty condition of the fused baryta prevents the ore from falling to the bottom, and thus keeps it in contact with the air. On cooling, the crucible and its contents are immersed in dilute nitric acid, which dissolves the greater portion of the mass, leaving the unattacked ore, which, after being washed, may be recalcined. The liquor containing the acid chromates of potassium and barium, nitrate of barium, sesquioxide of iron, alumina, and lime, is first heated with sulphate of potassium, which throws down the baryta as sulphate, which is collected on a filter and washed; ammonia and oxalate of ammonium are then added to throw down sesquioxide of iron, alumina, and lime; the mixed precipitate is collected and washed; and the amount of chromic acid determined as before.

5. *Atomic Weight of Chromium.*—Berzelius, in 1818 (Schw. J. xxii. 53), estimated the atomic weight of chromium from the composition of chromate of lead. 100 pts. nitrate of lead (containing 67·31 Pb^2O), yielded by precipitation with chromate of potassium, 98·772 pts. $PbO.CrO^3$; whence, taking the atomic weight of lead at 207·18, that of chromium was found to be 56·28.

Péligot, in 1844 (Ann. Ch. Phys. [3] xii. 528), showed that this number was too high. From the analysis of chromous chloride, $CrCl^2$, in which he found 56·7 to 58·4 per cent. chlorine, and likewise from that of the acetate, he estimated the atomic weight of chromium at 52·48.

Berlin (Ann. Ch. Pharm. lvi. 207; lx. 182) analysed chromate of silver by precipitating the silver with hydrochloric acid, then reducing the chromic acid in the filtrate to chromic oxide, and precipitating by ammonia. From the quantity of chloride of silver obtained (Ag = 108; Cl = 35·206), he found, as a mean of five experiments, Cr = 52·68, and by comparing the quantity of chromic oxide precipitated with the original quantity of chromate of silver, Cr = 52·54.

Berlin likewise adopted the method of Berzelius, and found that 100 pts. nitrate of lead yield from 97·559 to 97·594 pts. chromate of lead, whence, as a mean result, Cr = 51·98.

Moberg, in 1841 (J. pr. Chem. xliii. 114; xliv. 322), estimated the atomic weight of chromium by the analysis of chromic sulphate and of ammoniacal chrome-alum. From the quantity of chromic oxide in the sulphate dried at 300° C. he found Cr = 53·10, from that which remained after heating ammonio-chrome-alum to bright redness, Cr = 53·56.

Lefort, in 1850 (J. Pharm. [3] xviii. 27), determined the quantity of baryta in chromate of barium, by dissolving the salt in nitric acid and precipitating by sulphuric acid. In fourteen experiments he found that 100 pts. chromate of barium yielded 60·35 to 60·01 baryta; mean 60·19: whence, if Ba = 137·12, Cr = 53·28.

Lastly, **Wildenstein**, in 1853 (J. pr. Chem. lix. 27), determined the quantity of chromate of barium precipitated from chloride of barium by neutral chromate of potassium. As a mean of 32 experiments, he found that 100 pts. chromate of barium correspond to 81·70 of the chloride; the limits were 81·52 and 81·86. If then Ba = 137·12 and Cl = 35·46, the value of Cr is 53·52.

As the precipitation of baryta by sulphuric acid is affected by an error arising from the carrying down of a portion of the dissolved salt with the precipitated sulphate, and as moreover the atomic weight of barium is not very exactly known, it is probable that the determinations of the atomic weight of chromium by Berlin and by Péligot are the most exact, and the number 52·48 may be considered very near to the true value. (Handw. d. Chem. 2te Aufl. ii. [1] 482.)

CHROMIUM, FLUORIDES OF. *Chromic fluoride*, Cr^2F^6, is obtained by treating the sesquioxide, dried, but not ignited, with excess of hydrofluoric acid, and heating the dried mass very strongly in a platinum crucible. It is dark green, melts at a high temperature, and is but very slightly volatile, even at the melting point of steel. When subjected to the highest temperature produced by a lamp urged

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* The strength of a solution of dichloride of tin is most easily ascertained by means of a standard solution of acid chromate of potassium.

va, it sublimes in shining regular octahedrons (**Deville**, Ann. Ch. Pharm.
Berzelius obtained it as a green crystalline saline mass.
ic fluoride unites with the fluorides of ammonium, potassium, and sodium,
green sparingly soluble compounds.

luoride, CrF^6.—This compound, discovered by Unverdorben, is obtained by
1 pt. of chromate of lead with 1 pt. fluor spar and 3 pts. fuming oil of
a leaden retort, and collecting the vapours in a perfectly dry leaden receiver
very low temperature: it then condenses to a blood-red, strongly fuming liquid,
comes gaseous again at a temperature very little higher. The vapour is red,
n inhaled, produces violent coughing and severe oppression of the lungs. It
posed by water, forming hydrofluoric and chromic acids, and when it mixes
air, forms a thick white fume, coloured orange-yellow on the edges by minute
of chromic acid. With ammonia it unites, according to Unverdorben, forming
volatile body; but, according to Berzelius, it is decomposed with slight ex-
producing nitrogen gas, water, and hydrofluoric acid. Metals and other
agents, organic as well as inorganic, abstract part of the fluorine, leaving the
oride. Silicic acid decomposes it immediately, forming fluoride of silicium
mic acid; hence it corrodes glass; it may be kept, however, for a while in
sels coated with resin.

ose (Pogg. Ann. xxvii. 565), supposed that the formula of this compound was
cause it contains more fluorine than the formula CrF^6 requires, and its decom-
by water is attended with evolution of oxygen, as well as the formation of
and hydrofluoric acids. Berzelius, on the contrary, was of opinion that the
fluorine above 6 atoms arose from admixture of hydrofluoric acid, and that the
of oxygen in its decomposition by water, was due to the previous mixture of
with the vapour of the fluoride, inasmuch as the residue obtained in the pre-
of the compound always contains chromic oxide.

ride of intermediate composition between the sesqui- and tri-fluorides is ob-
solution by dissolving brown oxide of chromium in hydrofluoric acid. The
is red, and yields by evaporation a rose-coloured salt, which is redissolved
alteration by water, and precipitated brown by ammonia.

OMIUM, IODIDES OF. *Chromic iodide*, Cr^2I^6, is obtained in solution
ving chromic hydrate in hydriodic acid, or by treating chromate of silver
driodic acid and alcohol. It is green, and yields by evaporation a green
sidue, which splits into small pieces on cooling. It is insoluble in cold, easily
n warm water, but does not separate out again on cooling. No other iodide
nium is known with certainty.

OMIUM, NITRIDE OF. Cr^3N^4? This compound is produced when
loride of chromium is heated in a stream of ammonia-gas: probably thus:

$$3Cr^2Cl^6 + 26NH^3 = 2Cr^3N^4 + 18NH^4Cl + 3H^2;$$

f chlorochromic anhydride is treated in a similar manner. It is a brown
which, when heated to 150°—200° C. in a stream of oxygen, takes fire and
th a red light, giving off nitrogen gas and a small quantity of pernitric oxide,
ing trichloride of chromium. (**Liebig**, Pogg. Ann. xxi. 359.—**Schrötter**,
. Pharm. xxxvii. 148.—Gm. iv. 139.)

OMIUM, OXIDES OF. Chromium forms several compounds with oxygen,
the *protoxide*, CrO, the *sesquioxide*, Cr^2O^3, the *trioxide*, or *chromic anhydride*,
lso an oxide, Cr^3O^4, intermediate between CrO and Cr^2O^3, and several oxides
liate between Cr^2O^3 and CrO^3.

OXIDE OF CHROMIUM. CHROMOUS OXIDE, CrO. (**Moberg**, J. pr. Chem.
.—**Péligot**, Ann. Ch. Phys. [3] xii. 528.)—This oxide probably exists in some
ns of chrome-iron ore (p. 939) and in pyrope. It is precipitated as a hydrate
ction of potash on a solution of the protochloride. The anhydrous protoxide
been obtained. The hydrate, $2CrO.H^2O$, is very unstable, decomposes water
ordinary temperatures, and unless carefully protected from the air, by preci-
with a well-boiled solution of potash, is converted, as soon as it is formed, into
o-chromic oxide, with evolution of hydrogen. It must be dried in an atmo-
f hydrogen. It is yellow when recently precipitated, brown when dry, and
preserved unaltered in dry air. When ignited, it gives off hydrogen and leaves
ide: $2CrO.H^2O = Cr^2O^3 + H^2$.

nous hydrate is insoluble in dilute acids, but dissolves slowly in strong acids.
romous salts are most easily prepared by mixing a solution of the proto-
with the potassium or sodium-salt of the corresponding acid. They are
y of a red colour, sometimes inclining to blue, dissolve but sparingly in cold
nore readily in hot water. Like ferrous salts, they dissolve large quantities of

nitric oxide, forming dark brown solutions. (For their other reactions, see Dichloride of Chromium, p. 942.)

Chromoso-chromic oxide, Cr^3O^4, or $CrO.Cr^2O^3$.—Formed when protochloride of chromium is precipitated by potash without the precautions above mentioned for excluding the air. After washing in water and drying in the air, it has the colour of Spanish tobacco. It is but slightly attacked by acids.

Sesquioxide of Chromium. Chromic Oxide, Cr^2O^3.—This oxide exists in chrome-iron ore (p. 939) and in chrome-ochre. The latter occurs as a yellowish-green, earthy or argillaceous deposit generally mixed with clay, in the Shetland Isles, at Creuzot in France, at Halle and Waldenburg in Silesia, at Martenberg in Sweden, &c. (Dana, ii. 339). It is produced by heating chromium to redness in the air, by the ignition of chromic hydrate, by the decomposition of chromic anhydride and of various chromates, some of these processes yielding it in the amorphous, others in the crystalline state.

a. Amorphous. 1. When mercurous chromate is heated as long as oxygen and vapour of mercury are evolved, chromic oxide remains of a very fine green colour. It is best to heat the salt in a covered crucible, since, if the air has free access to it, part of the sesquioxide is converted into brown oxide, which impairs its colour. (Otto.) —2. When acid chromate of potassium is heated to redness with sulphur, the chromic acid is reduced, sulphurous anhydride is evolved, and there remains a mixture of chromic oxide with sulphide and sulphate of potassium, from which the soluble salts may be extracted by water. (Lassaigne, Ann. Ch. Phys. [3] xiv. 299.)—3. Berthier ignites chromate of potassium in a charcoal crucible, or mixes it with charcoal powder or lamp-black, and ignites it in an ordinary earthen crucible; dissolves the chromite of potassium produced in cold water; heats the filtrate to the boiling point; collects the precipitated hydrate on a filter; washes it thoroughly with water; and lastly ignites it. —4. Wöhler (Pogg. Ann. x. 46) ignites a mixture of acid chromate of potassium with about its own weight of sal-ammoniac and a small quantity of carbonate of sodium in a covered crucible, till no more vapour of sal-ammoniac is disengaged; and then purifies the sesquioxide of chromium from chlorides of potassium and sodium, by washing with water.—5. Barian (Rev. scient. xx. 425) mixes 4 pts. of acid chromate of potassium with 1 pt. of starch; ignites the mixture in a crucible; washes away the resulting carbonate of potassium with water; and again ignites the residue. He states that the chromic oxide thus obtained is so pure that it may be used for glazing porcelain.—6. When acid chromate of ammonium is heated in a platinum or porcelain basin over a lamp, a very energetic action takes place, accompanied by strong incandescence, and green bulky masses of chromic oxide shoot out in every direction, very much resembling unopened tea-leaves. (Böttger, Ann. Ch. Pharm. xlvii. 332.) —7. A very fine and intimate mixture is made of 48 pts. of gunpowder, 240 pts. of perfectly dry acid chromate of potassium, and 5 pts. of equally dry chloride of ammonium. This mixture is made into the shape of a cone (by pressing it into a wine glass, and afterwards carefully shaking it out) and then transferred to an iron plate. A burning fusee or other combustible is then applied to the top of the cone, whereupon it takes fire, and slowly burns throughout its whole mass. On exhausting the cone, while still hot, with water, a residue of chromic oxide is obtained in the form of a pale green powder. (Böttger, *loc. cit.*)

b. Crystallised. 1. When vapour of chloro-chromic anhydride is slowly passed through a glass tube heated to low redness, chlorine and oxygen are evolved, and chromic oxide remains in the tube as a crystalline deposit, sometimes interspersed with larger crystals (Wöhler, Ann. Ch. Pharm. lx. 203).—2. When acid chromate of potassium is heated to whiteness for eighteen hours, a mixture of the neutral chromate and chromic oxide is obtained; and on dissolving out the former with water, chromic oxide remains in fine iridescent spangles (Gentele, J. p. Chem. liv. 184).—3. When dry chlorine is passed over chromate of potassium heated to redness in a porcelain tube, the gas is completely absorbed, oxygen is evolved, and chloride of potassium is formed, together with chromic oxide, in long, shining, green, brittle tablets, if the tube is heated only to a dull redness, but in hard brown crystals like those obtained by Wöhler's method, if the temperature is raised to bright redness (Frémy, Ann. Ch. Pharm. xlix. 274). Blake (*ibid.* cii. 331) found chromic oxide crystallised in plates having the metallic lustre and belonging to the hexagonal system, in the cracks of a furnace which had been used for a long time for the preparation of chromate of potassium from chrome-iron ore.

Crystallised chromic oxide prepared by Wöhler's method forms crystals of rhombohedral character, greenish-black with metallic lustre, and as hard as corundum, so that they scratch glass. Their specific gravity is 5·21, and they yield a greenish powder by trituration.

Amorphous chromic oxide obtained by decomposing the hydrate at a temperature below redness, has a dark green colour; that which has been strongly ignited (methods

948) is bright green. When the oxide prepared at a moderate heat is gradu-
ed to a higher temperature, it suddenly becomes incandescent and is after-
early insoluble in acids. According to Berzelius, it then contains the indif-
nodification of chromium (p. 941). By ignition with nitrate or acid sulphate
sium, it may be brought back to the soluble state.

phous chromic oxide melts at the heat of a forge-fire, and on cooling forms
sh-black crystalline mass, exhibiting all the properties of the crystalline oxide
by Wöhler's method. It is not reduced by hydrogen gas. Charcoal reduces
intense white heat, but only at the points where it is in contact with the

nic oxide is used in the preparation of green glass and enamel, but especially
ainting of porcelain. It is also used in ordinary painting, forming one of the
rmanent greens, called **chrome-green.**

rated Chromic Oxide. Chromic Hydrates.—Chromic oxide forms
ydrates differing in their properties. When a solution of a green or violet
salt is mixed with potash or soda, a bluish-green hydrate is precipitated,
ssolves with emerald-green colour in excess of the precipitant, but is repre-
completely as green hydrate on boiling. With ammonia, the violet salts give
lue, the green salts a grey-green precipitate. Both these precipitates dissolve
acids, the former with red, the latter with green colour. In excess of am-
hey both dissolve slowly with peach-blossom colour, the greyish-blue pre-
however, the more abundantly of the two.

roperties of the hydrates precipitated by ammonia, are affected to a con-
extent by the concentration and temperature of the chromic solution and
mmonia, by the way in which they are mixed, &c.; and the results obtained
ent experimenters regarding the constitution and properties of these hydrates
o means accordant. L. **Schaffner** (Ann. Ch. Pharm. li. 168) describes three
tions of chromic hydrate: the first obtained by boiling chromic chloride with
f potash, and containing, according to **Ordway** (Sill. Am. J. [2] xxvi. 197),
I^2O, or $H^8Cr^2O^7$; the second, by treating the chloride with sufficient potash to
e the precipitate first formed, and neutralising the excess of alkali with
oric acid; the third, by precipitating a solution of a chromic salt with
f ammonia: the dried precipitate thus obtained is, according to Schaffner,
I^2O, or $H^{12}Cr^2O^9$.

ollowing results have been obtained by **Lefort** (J. Pharm. [3] xviii. 27).
chromic salt is treated with excess of caustic soda-solution, the precipitate
med redissolves with green colour if the original chromic salt was green or
bluish-violet colour if the chromic salt was bluish-violet. The solutions, if
leposit a gelatinous hydrate of fine green colour, containing $Cr^2O^3.5H^2O$, or
It becomes hard and black when dry, and yields a dark green powder.
e hydrate is obtained by pouring a chromic salt of either modification into
f the boiling alkali-solution.

er green hydrate, $Cr^2O^3.6H^2O$, or $H^{12}Cr^2O^9$, is deposited when the solution of
oxide in excess of alkali is left to itself. It exhibits the same properties as
eding (**Lefort**). According to Frémy, these hydrates contain 8 and 9 aq.
vely.

lrate containing $Cr^2O^3.7H^2O$, or $H^{14}Cr^2O^{10}$, is obtained when a solution of
nrome-alum is poured into excess of ammonia; the precipitated oxide then
d and redissolves, and, on heating the ammoniacal solution to a temperature
eding 50° C., a greyish-green pulverulent precipitate is formed, having the
tion just stated, and dissolving in acids with violet colour. (**Lefort.**)

$O^3.9H^2O$, or $H^{18}Cr^2O^{12}$.—This hydrate is deposited as a violet powder when the
acal-solution of chrome-alum is left to evaporate in the air or over oil of vitriol.
y, it forms a greyish-violet, very light powder; when dissolved in acids, it yields
(**Lefort.**)

ding to Frémy, this hydrate is obtained by precipitating a violet chromic salt
monia, and drying the precipitate in vacuo. It dissolves in acetic acid, am-
nd dilute potash-ley. Its properties are liable to considerable alteration from
ly trifling circumstances; thus, by the action of boiling water, or by prolonged
with cold water, by the action of concentrated saline solutions, by desiccation
ral days in the air or in vacuo, and trituration, it is rendered insoluble in
n which it was previously soluble. Frémy is of opinion that these alterations
om an allotropic modification of the chromic oxide, and not from loss of water.
ies the term **chromic oxide** to the oxide which has been rendered insoluble
acid, potash, and ammonia in the manner just mentioned, and **metachromic**
to that oxide which is soluble in these reagents, and is precipitated by am-
om a violet chromic salt.

A chromic hydrate, much used as a pigment, is the **emerald-green** of Pannetier, $Cr^2O^3.2H^2O = H^4Cr^2O^4$. It is prepared by melting in a crucible a mixture of equivalent quantities of boric anhydride and acid chromate of potassium, whereby chromic borate and borate of potassium are obtained, and treating the fused mass with water, which resolves the chromic borate into boric acid and chromic hydrate. By washing this hydrate and finely triturating it, a brilliant green powder is obtained. (**Guignet**, Rép. Chim. app. 1859, p. 158.)

Arnaudon (*ibid.* 201), by acting on acid chromate of potassium with phosphate of ammonium, likewise obtained a very fine green pigment, which appeared to be chiefly a chromic hydrate containing phosphoric acid.

For further details respecting the modifications of chromic hydrate, see Handw. d. Chem. 2te Aufl. ii. [2] 1221.

Chromic Salts.—The salts obtained by dissolving chromic oxide or hydrate in acids, correspond in composition to the oxide itself, containing, that is to say, 6 at. of monatomic acid radicle to 2 at. of chromium, or 3 at. of a diatomic acid radicle to 2 at. chromium, *e.g.* the nitrate $Cr^2(NO^3)^6$, the sulphate $Cr^2(SO^4)^3$. The most definite are the double sulphates, called chrome-alums, consisting of 1 at. chromic sulphate with 1 at. sulphate of an alkali-metal and 12 at. water, corresponding in composition to common alum, and crystallising in the same form, *e.g.* potassio-chromic sulphate,

$$K^2SO^4.Cr^2(SO^4)^3 + 12H^2O, \text{ or } K^2Cr^2(SO^4)^4 + 12H^2O = \left.\begin{matrix}4(SO^2)'' \\ K^2(Cr^2)^{vi}\end{matrix}\right\}O^8 + 12H^2O.$$

Chromic salts exhibit two modifications, the **green**, and the **red**, or **violet**, which pass easily one into the other. Thus, a solution of chrome-alum prepared in the cold has a violet colour, which changes to green on heating the solution, but reappears after it has been left to itself for some time. In many chromic salts the nitrate, for example, the change from green to violet takes place very quickly. The green solutions also take a bluish tint when heated with nitric acid. The violet appears to be the normal modification, inasmuch as the others always pass into it after a while; and it is only the violet solutions that yield crystallisable salts, the green solutions, when evaporated, leaving green amorphous masses.

Schrötter (Pogg. Ann. liii. 13) supposes that the change from the violet to the green modification by heat, is the result of a loss of chemically combined water, which is gradually resumed when the green solution is left at rest. **Otto** (Lehrbuch, 3 Aufl. ii. 93) remarks, in opposition to this view, that a red solution of chrome-alum does not turn green when mixed with strong sulphuric acid, provided rise of temperature be prevented.

Löwel (J. pr. Chem. xxxvii. 38) supposes that the different coloured solutions contain different proportions of acid and base, the red solutions containing normal chromic salts, such as $Cr^2(SO^4)^3$, or $Cr^2O^3.3SO^3$, and the green solutions basic salts of the form $Cr^2O^3.2SO^3$. This view receives some support from an observation of **Krüger** (Pogg. Ann. lxi. 218), that when a green solution of chrome-alum, obtained by boiling the salt with a very small quantity of water, is mixed with alcohol, the alcohol takes up a portion of the sulphuric acid, while the separated syrupy liquid contains the salt $K^2O.Cr^2O^3.3SO^3$. This salt, when dissolved in water, does not return to the violet modification unless a quantity of sulphuric acid be added to it sufficient to produce the normal salt $K^2O.Cr^2O^3.4SO^3$.

Frémy attributes the change of the violet salts into green by the boiling of their solutions, to a conversion of metachromic oxide into ordinary chromic oxide; this, however, can scarcely be called an explanation.

For the behaviour of chromic salts with reagents see pp. 943, 944.

Chromites.—Chromic oxide unites with protoxides, forming compounds of the form $M''O.Cr^2O^3$ or $M''Cr^2O^4$, which may be called chromites. The best known of these compounds is chrome-iron ore, in which, however, part of the chromium is usually replaced by aluminium and sometimes by iron. Lime, magnesia, and oxide of zinc, when they exist in solution with chromium, are sometimes precipitated by alkalis, when, if the chromium were not present, they would remain dissolved; thus, a solution of chrome-alum mixed with chloride of calcium yields with ammonia a green precipitate, consisting of $2CaO.Cr^2O^3$. On the other hand, bases which would otherwise be precipitated are sometimes retained in solution through the medium of chromic oxide; this is often the case with manganous and ferric oxide. In presence of 80 per cent. ferric oxide, however, chromic oxide is completely precipitated. These circumstances require to be carefully borne in mind in analysis.

Compounds of Chromic Oxide with Ammonia. (**Frémy**, Ann. Ch. Pharm. cx. 226.)—Chromic hydrate is slightly soluble in ammonia, and, under certain circumstances, takes up the elements of ammonia, forming peculiar metallic bases, designated by Frémy as **amido-chromium compounds**.

Chromic hydrate which has been subjected to the action of boiling water does not pon ammonia; but metachromic hydrate (p. 950), in contact with ammonia, res a violet colour, and forms the compound containing $2NH^3.Cr^2O^3$, which gives e whole of its ammonia when heated.

nmoniacal salts do not act on metachromic hydrate by themselves; but if am- a is likewise present, the hydrate dissolves, forming compounds of a beautiful t colour, which may be obtained in definite form by precipitating with alcohol and l drying in vacuo. The compound formed with ammonia and chloride of ammo- dissolves in water with deep violet-red colour. The solution has a scarcely ptible alkaline reaction, and does not yield any precipitate with nitrate of silver; f it be heated to the boiling point, ammonia is given off, chromic hydrate sepa- out, and the remaining liquid then gives a copious precipitate with nitrate of :. The products of the decomposition are $4NH^4Cl$, $8NH^3$, $3Cr^2O^3$, and H^2O.

the solution of the amido-chromium compound be left to itself for a while, it decom- , ammonia being evolved, sal-ammoniac being reproduced, and an insoluble violet being formed, which separates in round, transparent, iridescent granules. This likewise contains the elements of chromic oxide and ammonia. It is completely nposed by boiling water, the products of decomposition being in the ratio of $^3 : 2NH^3 : 12H^2O$. Acids convert it into a basic compound, $Cr^2O^3.8NH^3$, called o-chromammonia. With sulphuric acid the reaction is:

$$r^2O^3.2NH^3) + 12H^2SO^4 = \underset{\text{Sulphate of roseo-chromammonia.}}{(Cr^2O^3.8NH^3).3SO^3} + \underset{\text{Chromic sulphate.}}{3(Cr^2O^3.3SO^3)} + 12H^2O.$$

seo-chromammonia may likewise be obtained by the action of strong acids in the n the soluble amido-chromium compounds precipitated by alcohol from the rose- red liquids which are produced by the joint action of ammonia and ammonium-salts etachromic hydrate. The salts of this base have nearly a wine-red colour; the ochlorate crystallises in regular octahedrons, and forms crystallisable double salts mercuric and platinic chlorides. Pure water decomposes it into two new salts, rystallising in right rhombic prisms, the other remaining in solution. The bases ese two salts appear to differ from each other, and likewise from that of the hydro- ate from which they were produced. (Frémy.)

basic compound containing $Cr^2(CNS)^6.2(NH^4)^2O$, is obtained, by adding acid nate of potassium to fused sulphocyanate of ammonium. (Morland, Chem. Qu. J. xiii. 252.) (See SULPHOCYANATES.)

OWN OXIDES OF CHROMIUM. CHROMATES OF CHROMIUM.—These names pplied to certain oxides intermediate between the sesqui- and tri-oxides of chro- . They are obtained by gently heating chromic nitrate; by partial reduction of nic anhydride with alcohol, sulphurous acid, nitric oxide, or ferrous sulphate; y boiling a solution of chromate of ammonium; by digesting chromic acid with s of chromic oxide; by heating chromic anhydride above 250° C.; and by keeping nic oxide for some time, at 200° C., in contact with the air. A solution of acid nate of potassium, mixed with ammonia or with alcohol, likewise deposits a brown nent when exposed to sunlight, but not in the dark.

ese brown compounds, when heated, first give off water, if they are hydrated, and gher temperatures are reduced to chromic oxide; they dissolve in acids, forming n solutions, from which they are precipitated by ammonia without alteration. give off chlorine when heated with hydrochloric acid. Alkalis separate chromic rom them.

e brown oxides, obtained by different processes, exhibit considerable diversity of osition, and it is not exactly known whether they are distinct oxides of chromium mpounds of the sesqui- and tri-oxides. The compound obtained by heating nic hydrate in contact with the air, which has the composition CrO^2, or $Cr^2O^3.CrO^3$, garded by Krüger as a peroxide of chromium, CrO^2, because, when heated with uric acid and chloride of sodium, it gives off only chlorine and no chlorochromic dride, as all chromates do. A precipitate of the same composition is formed, ac- ng to Berzelius, on mixing neutral solutions of chromic chloride and chromate of sium. The precipitate thrown down by ammonia from a solution of chromic ate mixed with acid chromate of potassium, likewise gives off nothing but ine when similarly treated; according to Vogel, it is $CrO^2.H^2O$. The black ance obtained by heating chromic anhydride to 200° C. is, according to Traube, al chromate of chromium, $Cr^2O^3.3CrO^3$. It becomes soluble by boiling in water, rting to the water, first a yellowish, then a deep brown colour.

e precipitate formed on mixing the solutions of chrome-alum and neutral chromate tassium has, when dried at 100° C., the composition $3Cr^2O^3.2CrO^3.9H^2O$. The obtained by reducing chromic anhydride with alcohol, has, according to Traube, ame composition. It is insoluble in water; dissolves in hydrochloric acid with yellow, in nitric and in hot dilute sulphuric acid with brown colour. The solutions yield with ammonia a precipitate of sesquioxide, while chromic acid remains in solution. Potash quickly resolves it into chromic oxide and chromic acid.

Chromic hydrate digested with excess of chromic acid, yields a dark brown solution, which dries up to a residue soluble in alcohol, and containing, according to Maus, $Cr^4O^3.4Cr^2O^3$, or Cr^4O^5. (Handw. d. Chem. 2te Aufl. ii. [2] 1236.)*

TRIOXIDE OF CHROMIUM. CHROMIC ANHYDRIDE. *Anhydrous Chromic Acid.* CrO^3.—This oxide may be regarded as a constituent of the chromates, the formula of a neutral chromate being M^2CrO^4, or $M^2O.CrO^3$. It is obtained in the free state:

a. By decomposing trifluoride of chromium with a small quantity of water.—The vapour of the trifluoride, evolved by distilling chromate of lead and fluor spar with fuming sulphuric acid, is passed into a large platinum crucible, slightly moistened on the inside and closed with moist paper. The trifluoride is then decomposed by the aqueous vapour, with which the air in the crucible is charged, into hydrofluoric acid and beautiful red needles of chromic anhydride, which fill the crucible.

b. By decomposing a chromate with sulphuric acid.—Chromic anhydride is easily prepared by pouring 1 vol. of a saturated solution of acid chromate of potassium in a thin stream into 1½ vol. strong sulphuric acid, stirring all the while. As the liquid cools, chromic anhydride crystallises from it in splendid crimson needles often an inch long. The mother-liquor is decanted, and the crystals are drained on a porous tile till they are nearly dry, and then purified by recrystallisation. For many purposes for which chromic acid is used, the presence of a certain quantity of sulphuric acid is not objectionable, so that the purification may be dispensed with.

Bolley (Ann. Ch. Pharm. lvi. 113) prepares chromic anhydride by dissolving a weighed quantity of acid chromate of potassium in a small quantity of boiling water, and adding to the hot solution the exact quantity of sulphuric acid required to form acid sulphate of potassium. The mixture when left to cool, solidifies for the most part into a red granular mass consisting of acid sulphate of potassium with adhering chromic anhydride. The mixture is stirred to cause the granular mass to subside; the solution is decanted; and the residual acid sulphate is washed several times with cold water. There then remains an orange-coloured sulphate of potassium with very little chromic acid, the greater part of that acid being contained in the united solutions. The separation thus effected depends upon the circumstance that acid sulphate of potassium, which dissolves very freely in boiling water (2 pts. of the salt to 1 pt. of water), is but sparingly soluble at ordinary temperatures, and cold water removes sulphuric acid from it with scarcely any potash, leaving neutral sulphate of potassium, while the chromic acid dissolves in the cold water. The solution of chromic acid containing only a small quantity of acid sulphate of potassium is then further concentrated, and the chromic anhydride is precipitated by adding about an equal volume of strong sulphuric acid, which throws it down free from any trace of acid sulphate.

Chromic anhydride may also be prepared by decomposing chromate of lead with strong sulphuric acid, diluting with water after twenty-four hours, to precipitate sulphate of lead, then filtering and evaporating to the crystallising point, or by decomposing chromate of barium with strong nitric acid, filtering the liquid from the resulting nitrate of barium, which is insoluble in the strong acid, and heating the filtrate till the excess of nitric acid is expelled, and crystallising as above.

Pure chromic anhydride forms either a red powder, a red loose woolly mass, or scarlet crystals. It deliquesces in damp air and dissolves in a small quantity of water, forming a dark brown liquid having a sour astringent taste and yellow or brownish yellow on dilution. The solution contains chromic acid, but when evaporated it yields the anhydride: indeed chromic acid is not known in the solid state.

Chromic anhydride melts at 190° C., and begins to decompose at 250°, giving off oxygen and leaving a brown oxide or chromate of chromium, which, when further heated, is reduced to sesquioxide. Chromic anhydride is a powerful oxidising agent, being quickly reduced to sesquioxide of chromium by *sulphydric acid, zinc, arsenious acid, tartaric acid, sugar, alcohol,* and various other organic bodies, especially when heated. With *sulphydric acid* it forms water and sets sulphur free: $2CrO^3 + 3H^2S = Cr^2O^3 + 3H^2O + S^3$; with *hydrochloric acid* it yields trichloride of chromium, water, and free chlorine: $2CrO^3 + 12HCl = Cr^2Cl^6 + 6H^2O + 3Cl^2$. *Sulphurous acid* added to a solution of chromic acid or a chromate throws down a brown chromate of chromium, consisting of $Cr^2O^3.CrO^3$ or CrO^2. A few drops of *anhydrous alcohol* poured upon chromic anhydride instantly reduce it to sesquioxide, the alcohol sometimes taking fire. A similar reduction attended with incandescence

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* From recent experiments by Storer and Eliot (Proc. Amer. Acad. v. 192), it appears that there is but one definite oxide of chromium intermediate between Cr^2O^3 and CrO^3, viz. CrO^2 or $Cr^2O^3.CrO^3$. The authors have likewise obtained the analogous compounds, $Al^2O^3.CrO^3$, $Fe^2O^3.CrO^3$, and Mn^2O^3 CrO^3.

ace when a small quantity of the anhydride is introduced into an atmosphere
ol vapour, or of alcohol or ether vapour mixed with sulphide of carbon. Dry
a gas suddenly directed upon perfectly dry chromic anhydride, renders it in-
ent and converts it into chromic oxide, while nitrogen and aqueous vapour are
f. Aqueous chromic acid bleaches vegetable colours.

nic acid in the free state is sometimes used practically as an oxidising agent,
e frequently a mixture of sulphuric acid and chromate of potassium, which
t.

n crystallised chromic anhydride is added to strong sulphuric acid as long as it
s, an ochre-yellow, pasty, very hygroscopic substance is formed, containing.
g to **Bolley** (Ann. Ch. Pharm. lvi. 113), $H^2SO^4.CrO^3$. When exposed to the
uickly turns red from separation of chromic anhydride. **Schrötter** (Pogg.
. 616) obtained in like manner a yellow-brown sediment, which he represents
nately by the formula $CrO^3.3SO^3$.

CHROMIC ACID. $H^2Cr^2O^8$ or $H^2O.Cr^2O^7$?—When peroxide of hydrogen dis-
n water is mixed with a solution of chromic acid, the liquid assumes a deep
blue colour, but often loses this colour very rapidly, giving off oxygen at the
me. The same blue colour is produced on adding a mixture of aqueous per-
f hydrogen and sulphuric or hydrochloric acid to acid chromate of potassium;
very short time oxygen is evolved, and chrome-alum is left in solution. For
om of acid chromate of potassium, $K^2O.2CrO^3$, 4 at. of oxygen are evolved,
d an excess of peroxide of hydrogen be present. We may, therefore, suppose
rchromic acid, $H^2Cr^2O^7$, is first formed by the union of H^2O with $2CrO^3$, and
rds resolved into oxygen and chromic hydrate, $H^2Cr^2O^7 = H^2O.Cr^2O^3 + O^4$.
ther, perchromic anhydride forms a more stable solution than with water. The
l solution, which has a deep blue colour, may be obtained by treating peroxide
im with hydrochloric or nitric acid, pouring ether on the liquid, gradually add-
olution of acid chromate of potassium, and agitating. Perchromic acid is de-
ed by aqueous alkalis, with formation of a chromate and evolution of oxygen;
monia and certain organic bases dissolved in ether and added to the ethereal
of the acid, form stable compounds, from which stronger acids separate the
id. The most stable of these compounds is the quinine salt, which is soluble in
insoluble in ether, and may be dried without decomposition. (**Barreswil**,
rend. xvi. 1085.)

recent investigations of **Aschof** (*Inaugural-Dissertation über die Uebermangan-
nd Ueberchromsäure*, Berlin, 1861) tend strongly to confirm the formula Cr^2O^7
othetical perchromic anhydride. He also finds that when the deep blue ethereal
of perchromic acid is shaken up with such a quantity of very dilute aqueous
that the ethereal layer shall still exhibit a faint blue tint, the aqueous, per-
eutral liquid below exhibits a peculiar deep bluish-violet tint, which is tolerably
but if more potash be added, the colour changes to the light yellow of neutral
te of potassium, while bubbles of oxygen are given off. Hence it appears that
e colour belongs to the free acid, the violet to its salts.

rding to **Storer** (J. pr. Chem. lxxxi. 44) the colouring power of perchromic
so great, that when a solution of 1 pt. acid chromate of potassium in 30,000 to
pts. water is shaken up with ether containing peroxide of hydrogen, the ether
s a perceptible blue tint; he therefore recommends this reaction as a very deli-
st for chromic acid. **Schönbein** (*ibid.* lxxix. 65) applies it as a test for per-
f hydrogen.

ROMIUM, OXYCHLORIDES OF. Four of these compounds are known,
which may be regarded as compounds of sesquioxide and sesquichloride of chro-
and the fourth (the so-called *chlorochromic acid*), as a compound of the tri-
e and trioxide. They may also be regarded as derived from the trichloride or
hloride by the substitution of oxygen for part of the chlorine.

ompounds of Sesquichloride and Sesquioxide of Chromium.—These compounds,
h three have been distinguished, are obtained by evaporating the green solu-
the sesquichloride, and heating the residue to different temperatures. By dry-
20° C. a reddish tumefied mass is left, containing $4Cr^2Cl^6.Cr^2O^3 + 24H^2O$, or
$O^3 + 24H^2O$.

ying at 150° C., with constant stirring, a greyish red deliquescent powder is
l, consisting of $2Cr^2Cl^6.Cr^2O^3 + 8H^2O = 3Cr^2Cl^4O + 8H^2O$, or, according to
$CrO^2Cl^2.2HCl + H^2O$. If this compound be heated to redness, it becomes
insoluble in water, and the undissolved portion consists of $Cr^2Cl^6.2Cr^2O^3$ or
^{3}. It is greyish-red by daylight, green by lamplight, like neutral chromic
. By prolonged ignition in contact with the air, it is completely converted
quioxide. (**Moberg.**)

Chrysammic acid is a yellow powder, often light yellow or greenish yellow, and consisting of small shining scales. It is sparingly soluble in cold, more easily in boiling water. The solution has a deep purple colour, tastes bitter, and reddens litmus. It dissolves easily in alcohol and ether; also in nitric acid and in saline solutions.

The acid detonates violently when subjected to dry distillation, emitting a bright but smoky flame, and diffusing an odour of bitter almonds, together with nitrous vapours. Heated in *chlorine gas*, it gives off hydrochloric acid. Boiled with *caustic potash*, it forms a brown solution from which acids throw down a dark brown precipitate (Schunck's *aloeretic acid;* Mulder's *chrysatic acid*), soluble in pure water, forming soluble salts with the alkalis and earths, insoluble with lead and silver. If the potash is very strong, ammonia is likewise evolved. Chrysammic acid is not attacked by *fuming nitric acid* (Schunck). With strong *sulphuric acid* at the boiling heat, it reacts violently, giving off copious red fumes containing carbonic anhydride, carbonic oxide, sulphurous anhydride, and nitrous anhydride. At the same time a dark violet-coloured substance is deposited (Mulder's *chryiodine*), soluble in potash and reprecipitated by hydrochloric acid, as a gelatinous mass of the same colour. This product appears to be only a mixture, for ammonia separates it into a soluble and an insoluble portion. *Sulphide of potassium* mixed with caustic potash, transforms chrysammic acid into hydrochrysamide: a similar blue substance (Mulder's *chrysindinammonium*) is obtained by decomposing a warm ammoniacal solution of chrysammic acid with sulphuretted hydrogen. *Ammonia* converts chrysammic acid into chrysamide. The acid boiled with water and *stannous chloride*, forms a powder which has a deep violet colour, is nearly insoluble in all solvents ($C^{14}H^4N^2O^{11}.3SnO^2$, according to Mulder), gives off ammonia and assumes a fine blue colour when treated with potash, and is decomposed by nitric acid, yielding aloëtic and chrysammic acids.

The **chrysammates** mostly crystallise in small scales, and exhibit a gold-green metallic lustre on the crystalline faces; those which are amorphous, exhibit the same lustre when rubbed with a hard body. They detonate violently when heated. They are all sparingly soluble, even those of the alkali-metals. In solutions of acetates they dissolve more easily than in water, but less when heated than in the cold.

Chrysammate of Ammonium changes rapidly into chrysamide.

Chrysammate of Barium, $C^{14}H^2Ba''N^4O^{12} + 4aq.$, is obtained as a vermilion-coloured precipitate by mixing a solution of the potassium-salt with chloride of barium; also by prolonged boiling of chrysammic acid with chloride of barium. It is quite insoluble in water.

Chrysammate of Cadmium is a dark purple precipitate.

Chrysammate of Calcium is a dark red insoluble powder, exhibiting traces of crystallisation.

Chrysammate of Copper, $C^{14}H^2Cu''N^4O^{12} + x aq.$, is sparingly soluble in cold, more soluble in boiling water, from which it separates in dark purple needles, exhibiting a golden lustre by reflected light: its solution has a fine purple tint.

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Chrysammate of Magnesium resembles the calcium-salt.

Chrysammate of Potassium, $C^7HKN^2O^6$, crystallises in flat rhomboïdal plates, which exhibit very remarkable relations to polarised light. Light transmitted through one of them, exhibits a reddish-yellow colour and becomes polarised in one plane; but if the crystal be pressed with the blade of a knife on a plate of glass, it spreads on the glass like an amalgam, and a beam of light, transmitted through the thin film thus formed, splits into two rays polarised in planes perpendicular to each other, one having a carmine-red, the other a pale yellow colour. As the thickness of the film increases, the colour of both rays approaches more and more to carmine-red. Still more remarkable phenomena are exhibited by reflected light. An ordinary ray of white light reflected perpendicularly from the face of a crystal or from a film, has the colour of virgin-gold, but as the incidence becomes more oblique, the colour becomes less and less yellow, and at length passes into pale blue. The beam thus reflected is composed of two rays oppositely polarised; the one which is polarised in the plane of reflection remains of a pale blue colour at all angles of incidence; the other, polarised at right angles to the plane of reflection, has a pale-yellow colour at small inclinations, then changes to deep yellow, greenish-yellow, green, bluish-green, blue and violet. (**Brewster**, *Gerhardt's Traité*, iv. 251.)

Chrysammate of potassium dissolves in 1250 pts. of cold water, easily in boiling water; the solution has a fine red colour.

Chrysammate of Silver. Dark brown precipitate, quite insoluble in boiling water.

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RYSANTHEMUM SEGETUM. The ash of this plant has been analysed
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al.

RYSATRIC ACID. (Mulder, J. pr. Chem. xlviii. 16.) *Aloeretic acid.*
unck, Ann. Ch. Pharm. lv. 240.)—An acid produced by heating chrysammic
vith alkalis. Chrysammic acid heated with potash-ley dissolves, forming a brown
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nium-salt yields with acetate of lead, a brown precipitate containing, according
nningen's analysis, 58·71 per cent. PbO, 19·08 C, 0·78 H, and 5·51 N. With
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·82 H. (Schunk.) These analyses do not lead to any satisfactory formula.

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t 100° C, 8·52 per cent. ash (63·3 per cent. of which was soluble in water). The
ntained in 100 pts.: 24·86 K^2O, 6·21 Na^2O, 14·08 CaO, 6·96 MgO, trace of
nese, 5·12 SO^3, 12·36 CO^2, 6·16 P^2O^5, 4·68 SiO^2, 16·10 NaCl, with 3·06 sand and
al.

RYSATRIC ACID. (Mulder, J. pr. Chem. xlviii. 16.) *Aloeretic acid.*
nck, Ann. Ch. Pharm. lv. 240.)—An acid produced by heating chrysammic
ith alkalis. Chrysammic acid heated with potash-ley dissolves, forming a brown
n, from which, according to Mulder, acetic acid does not precipitate anything;
ing to Schunck, however, a brown precipitate is obtained. The solution of the
ium-salt yields with acetate of lead, a brown precipitate containing, according
nningen's analysis, 58·71 per cent. PbO, 19·08 C, 0·78 H, and 5·51 N. With
e of barium, a precipitate is formed, containing 30·80 per cent. BaO, 28·03 C,
32 H. (Schunk.) These analyses do not lead to any satisfactory formula.

CHRYSENE, nC^6H^4. (Laurent, Ann. Ch. Phys. [2] lxvi., 136.)—A crystalline hydrocarbon obtained, together with *pyrene*, by the dry distillation of fats, resins, and coal: it may be extracted from coal-tar by redistillation. The products which pass over towards the end of the process, consist of a soft yellow or reddish mass, and a thick oil containing crystalline scales. That which condenses in the neck of the retort is chiefly chrysene, the pyrene passing for the most part into the receiver. By treating the mass in the neck of the retort with ether, the pyrene and certain oily matters are dissolved out, while the chrysene remains in the pulverulent state.

Pure chrysene has a fine yellow colour; it is crystalline, destitute of taste and odour, insoluble in water and alcohol, nearly insoluble in ether: oil of turpentine dissolves it at the boiling heat, and deposits it on cooling in yellow crystalline flakes. It melts at 230° — 235° C., and solidifies on cooling to a deep yellow mass composed of needles. At a higher temperature, it distils with slight alteration.

Nitrochrysene, $nC^6H^3(NO^2)$, produced by the action of strong boiling nitric acid on chrysene, is a red powder, destitute of taste and odour, insoluble in water, nearly insoluble in alcohol and ether. It is dissolved with brown colour by sulphuric acid, partially also by alcoholic potash. When quickly heated in a closed tube, it melts and decomposes with explosion.

CHRYSINDIN. A product of the decomposition of chrysammic acid by ammonia. (Mulder, p. 956.)

CHRYSOBERYL. *Cymophane*, *Chrysopal*.—An aluminate of glucinum, $Al^2Gl''O^4$, or $Gl''O.A^2O^3$, generally containing 2 or 3 per cent. of iron. It is usually found in round pieces about the size of a pea, but sometimes in eight-sided prisms with six-sided summits, belonging to the trimetric system. Specific gravity 3·5 — 3·7. Hardness 8·5. Lustre vitreous. Colour various shades of green. Streak uncoloured. Transparent or translucent, sometimes with bluish opalescence internally. Fracture conchoïdal, uneven. It exhibits double refraction, and becomes electric by friction. It is infusible alone before the blowpipe, and very difficult to fuse with borax or phosphorus-salt. With carbonate of sodium, the surface is merely rendered dull. It is not acted upon by acids.

Chrysoberyl is found in Brazil and Ceylon, in rolled pebbles, in the alluvial deposit of rivers; and in granite at Haddaw, Connecticut, Greenfield, near Saratoga, New York, and Orange Summit, Vermont. When transparent and of sufficient size, it is cut into facets and forms a gem.

Crystals of chrysoberyl have been formed artificially by exposing a mixture of alumina and glucina in the proper proportion, together with boracic acid as a flux, to the heat of a pottery furnace for several days, till the boracic acid is completely volatilised (Ebelmen, Ann. Ch. Phys. [3] xxii. 211; xxxiii. 34). [For the crystalline form of the artificial chrysoberyl, see Jahresber. d. Chem. 1851, p. 765.]

A variety of chrysoberyl called *Alexandrite*, from the Ural, exhibits pleochroism, viz. by perfectly white light, an orange-yellow colour in the direction of the longer diagonal of the base, colombo-red along the shorter diagonal, and emerald-green along the principal axis. (Haidinger, Pogg. Ann. lxxvii, 228.)

CHRYSOCOLLA. The Greek name for borax. Applied also to silicate of copper.

CHRYSOHARMINE. Syn. with NITROHARMALINE (*q. v.*)

CHRYSOIDIN. $C^7H^{22}O^4$?—A yellow colouring matter said to exist in very small quantity in asparagus-berries.

CHRYSOLEPIC ACID. Syn. with PICRIC ACID.

CHRYSOLITE. *Peridote*, *Olivin*.—A silicate of magnesium and iron, $(Mg;Fe)^4SiO^4$, occurring in basalt and lavas, in prismatic crystals of the trimetric system, also massive and compact or granular; colour olive and other shades of green. The term *Chrysolite* includes the transparent crystals of paler colour, while *Olivine* (so-called from the olive-green tint) is applied to imbedded masses or grains of inferior colour and clearness. (See OLIVINE.)

CHRYSOMELANE. Syn. with PLEONAST.

CHRYSOPAL. Syn. with CHRYSOBERYL.

CHRYSOPHANE. See CLINTONITE.

CHRYSOPHANIC ACID. *Chrysophane*, *Rhubarbaric acid*, *Rhubarbarin*, *Rhubarb-yellow*, *Rhein*, *Rheic acid*, *Rheumin*, *Rhaponticin*, *Rumicin*, $C^{10}H^8O^3$, or $C^7H^{10}O^2$. The yellow colouring principle of rhubarb and of the wall lichen (*Parmelia parietina*). It was first obtained in an impure state by Herberger, Dulk, and Brandes, afterwards analysed by Rochleder and Heldt (Ann. Ch. Pharm. xlviii. 12), who extracted the pure substance from the *Parmelia;* also by Döpping and Schlossberger (*ibid.* l. 215), by De La Rue and Müller (Chem. Soc. Qu. J. x. 298) and by Thann (Ann. Ch. Pharm. cvii. 324), who obtained it from rhubarb.

Preparation from Parmelia parietina.—The dried lichen is digested in the cold with alcoholic potash or ammonia; the dark red infusion is filtered and mixed with acetic acid; the bulky yellow flocks thereby precipitated are washed with water and redissolved in alcoholic potash, a certain quantity of resin then remaining undissolved; the liquid is again precipitated by hydrochloric acid; and the precipitate, after washing and drying, is redissolved in a small quantity of boiling absolute alcohol. The solution then deposits chrysophanic acid in the crystallised state.

From Rhubarb.—Dulk prepared chrysophanic acid from rhubarb by exhausting the root with alcoholic ammonia, precipitating with subacetate of lead, and decomposing the precipitate, suspended in alcohol, with sulphuretted hydrogen. Schlossberger and Döpping exhaust the pulverised rhubarb with 80 per cent alcohol; evaporate; redissolve in a small quantity of alcohol; add ether to the solution to precipitate certain resinous matters; evaporate the filtered solution to the crystallising point; and purify the chrysophanic acid thus obtained by repeated crystallisation from boiling absolute alcohol.

De la Rue and Müller find that chrysophanic acid may be extracted from rhubarb with much greater facility by means of benzene or the light hydrocarbons obtained from Burmese naphtha, these liquids dissolving it very readily, to the exclusion of the greater part of the other constituents. The crushed root is first macerated in water, which removes about 50 per cent. of soluble matter, then dried and treated with benzene in a Mohr's displacement apparatus; the greater part of the benzene is then distilled off; the residue, which becomes nearly solid on cooling, is pressed between blotting paper to remove the mother-liquor which contains erythroretin and a neutral fat; the crude chrysophanic acid thus obtained is redissolved in hot benzene, which leaves behind a reddish-yellow substance (*emodin*), an additional quantity of which separates as the solution cools; and the chrysophanic acid, which afterwards crystallises out, is further purified by recrystallisation from acetic acid, amylic alcohol, or common alcohol. The residuary rhubarb, thrown away in pharmaceutical laboratories after the preparation of the ordinary alcoholic tincture, may be advantageously used for the preparation of chrysophanic acid by this process, inasmuch as it contains about 2·6 per cent. of that acid, which is but slightly soluble in alcohol, especially in the weak spirit used in the preparation of the tincture. The dark coloured resinous sediment which separates from *Tinctura Rhei* when left to itself, is also rich in chrysophanic acid, and may be subjected to the same treatment.

Thann extracts the root of *Rumex obtusifolius* with ether; distils off the greater part of the liquid; washes the dark yellow-brown mass which separates on cooling with a small quantity of ether; dries it between bibulous paper; boils the residue with 90 per cent. alcohol; dissolves the dirty green granular mass which separates on cooling with alcohol and precipitates by water, repeating the solution and precipitation several times; purifies the product by treatment with alcoholic ammonia and acetic acid, as in Rochleder and Heldt's process; then crystallises it from alcohol, and lastly from ether by slow evaporation.

Chrysophanic acid crystallises from benzene in six-sided tables (monoclinic), having a pale yellow or orange-yellow colour; from alcohol, amyl-alcohol, or glacial acetic acid, in moss-like aggregates of laminar crystals. It is sparingly soluble in cold water; dissolves in 224 pts. of boiling alcohol of 86 per cent.; in 1125 pts. of the same alcohol at 30° C. It is soluble also in ether and in oil of turpentine, coal-naphtha, benzene, and other hydrocarbons (*vid. sup.*) It melts without decomposition at 162° C. and solidifies in the crystalline form on cooling.

The formula of chrysophanic acid is not quite settled. The analyses by Rochleder and Heldt, and by Schlossberger and Döpping, approach nearly to the formula $C^{10}H^8O^3$, while those by De la Rue and Müller, and by Thann, agree better with $C^{14}H^{10}O^4$.

	Calculation. $C^{10}H^8O^3$	Rochleder and Heldt.	Schlossberger and Döpping.	De la Rue and Müller.	Thann.	*Calculation.* $C^{14}H^{10}O^4$
Carbon .	. 68·18	68·03	68·12	68·76	69·62	69·42
Hydrogen	. 4·55	4·57	4·59	4·25	4·39	4·13
Oxygen .	. 27·27	,,	,,	,,	,,	26·45
	100·00					100·00

Chrysophanic acid subjected to dry distillation, partly sublimes, while another portion becomes carbonised. Dilute nitric acid does not appear to act upon it, even at the boiling heat, but the strong acid converts it into a red substance. Strong sulphuric acid dissolves without decomposing it, and water precipitates it from the solution.

The acid dissolves in alkalis with fine deep purple colour: the reaction is very delicate, so that a dilute solution of chrysophanic acid may be used as a test for alkalis. Its solution in potash may be evaporated to dryness without alteration; but at a certain degree of concentration, it deposits blue or violet flocks, which redissolve in water or alcohol, forming red solutions. If the purple solution of the acid in moderately strong potash, together with the flocculent precipitate, be mixed with grape sugar and left to stand in a closed vessel, the alkali being in excess, the colour of the liquid gradually changes to brownish-yellow, and the precipitate disappears: on subsequent exposure to the air, the original colour and the precipitate are reproduced. Hydrate of potassium at its melting point does not act on chrysophanic acid at first; but if the heat be continued or increased, the liquid turns blue and decomposes, emitting an odour like that of octylic alcohol. (De la Rue and Muller.)

With baryta and oxide of lead, chrysophanic acid forms very unstable compounds, which are decomposed even by the carbonic acid in the air. Its alcoholic solution forms with alcoholic subacetate of lead, a reddish-white precipitate, which changes to rose-red by boiling with water; no precipitate with neutral acetate of lead. The ammoniacal solution of chrysophanic acid yields with neutral acetate of lead, a lilac; with alum, a beautiful rose-coloured precipitate. (Thann.)

CHRYSOPRASE. An apple-green or leek-green variety of chalcedony, coloured by nickel.

CHRYSOPRASE EARTH. See PIMELITE.

CHRYSORETIN. A yellow resin obtained from senna-leaves by evaporating the aqueous extract, treating the residue with alcohol, evaporating, dissolving in ether, and again evaporating. It is a mixture of several substances, perhaps containing chrysophanic acid, or a similar acid. (Bley and Diesel, Jahresber. 1848, p. 828.)

CHRYSORHAMNIN. A yellow crystalline substance contained in Persian berries or yellow berries (*graines d'Avignon*, *Krautz-beeren*), the fruit of *Rhamnus amygdalinus*, *R. oleoïdes*, *R. saxatilis*, *&c.*, especially in the unripe state. According to Kane (Ann. Ch. Phys. [3] viii. 380), it may be extracted from the berries by ether, in which it is easily soluble. It is nearly insoluble in cold water, soluble in alcohol, and contains 58·02 per cent. carbon, and 4·7 hydrogen, whence Kane deduces the formula $C^{23}H^{22}O^{11}$. By boiling with alcohol or water, it is decomposed, yielding another colouring matter, *Xanthorhamnin*, $C^{23}H^{24}O^{11}$, which is soluble in water and alcohol, but insoluble in ether.

Gellatly (Edinb. N. Phil. J. vii. 252), by treating Persian berries with ether, obtained neither chrysorhamnin nor any other characteristic substance; but with alcohol, he obtained a yellow substance crystallising in needles, which appeared to be xanthorhamnin.

According to Bolley (Chem. Soc. Qu. J. xiii. 327), Persian berries yield an abundant extract when treated with *crude ether* (this may perhaps explain the difference between the statements of Kane and Gellatly); and on evaporating the ether, dissolving the residue in alcohol, filtering, and evaporating with addition of water, stellate groups of yellow needles are obtained, which are not altered by repeated solution, boiling, and precipitation. They gave, by analysis of two specimens, 58·87 and 60·239 per cent. carbon, 4·66 and 4·18 hydrogen. The crystals were somewhat soluble in pure ether, sparingly in water, easily in alcohol. The solution gives with neutral acetate of lead, a brick-red precipitate; with nitrate of silver, a blood-red liquid, and afterwards reduced silver. Hence, and from the analysis, Bolley concludes that this substance is quercetin (*q. v.*)

CHRYSOTILE. See SERPENTINE.

CHULARIOSE. Uncrystallisable sugar. (See SUGAR.)

CHUSITE. See OLIVINE.

CHYLE. (Lehmann, *Gmelin's Handbuch*, viii. 216; *Physiological Chemistry*, ii. 281.—Pelouze and Frémy, *Traité*, vi. 162).—Chyle is that portion of the products of digestion which is absorbed by the lacteal vessels terminating in the inner surface of the small intestines, chiefly the jejunum, and thence passing by numerous converging streams into the main trunk of the absorbent system, called the thoracic duct, through which it is gradually poured into the blood of the left subclavian vein, at a short distance before it enters the right side of the heart.

The physical properties of chyle differ according to the nature of the animal to which it belongs, the condition of the animal, whether lately fed or fasting, and the nature of the food which has been taken. Chyle obtained from the thoracic duct during digestion, is an opalescent, milky, yellowish-white or pale red liquid, having a faint, peculiar odour, a somewhat saline and mawkish taste, and very weak alkaline reaction; its specific gravity varies from 1·012 to 1·022. Nine or ten minutes after removal from the vessels, it coagulates; the coagulum, which contracts in from two to four hours, is smaller in bulk compared with the serum than that of blood; it is very soft, easily torn, and sometimes gelatinous. If of a yellow colour, it generally becomes somewhat reddish on exposure to the air, an effect especially observed in the chyle of horses. The serum of chyle, after separation from the coagulum, is never quite clear; it does not usually become turbid when mixed with water; on boiling with water, a urbidity appears in the liquid, which, however, generally deposits only a few lots. Acetic acid often produces a turbidity in the serum, and the filtered vhen evaporated exhibits on its surface, colourless, transparent films of albumi- sodium. Ether does not coagulate chyle-serum, but renders it clearer, and the ether and the serum there is formed a cream-like stratum of a dirty sh-white colour.

chyle of birds, amphibia, and fishes, is nearly transparent and colourless; in it is of a deeper red colour than in any other animals which have been ed with reference to this subject. That of carnivora is comparatively thick and that of herbivora, thinner and more transparent; in cats, it is of a perfectly whiteness, whatever may be the nature of their food. During digestion, the s for the most part very turbid; at other times it forms a faintly opalescent xhibiting a reddish colour only in the thoracic duct.

morphological elements of the chyle, are: 1. Extremely small granules, consist- drops of fat enclosed in an albuminous envelope.—2. Granules bound together yaline substance, with or without nuclei, and separate granules with distinct .—3. The so-called chyle-cells, 0·002 to 0·0055 of a line in diameter, the granules h mostly become visible on addition of water or acetic acid.—4. The transition f the several structures from the more simple to the more complex.—5. A small y of coloured blood-cells, especially in the chyle of the thoracic duct.

hemical constituents of chyle are very nearly the same as those of the intercellular the blood. It is difficult, however, to obtain chyle of constant composition, because it varies with the quality and quantity of the food taken, partly because vays more or less mixed with lymph and blood.

fibrin of chyle is in general less contractile and more gelatinous than that of like the fibrin of many pathological exudations, and that of fish, it sometimes ves after coagulation, especially if heated; it is usually destitute of the fibrous re of blood-fibrin; dissolves very easily in dilute alkalis, carbonic acid, and acids; also, after a while, in solution of nitre, and even in sal-ammoniac; from tion in acetic acid, it is completely precipitated by sal-ammoniac, and from its n in sal-ammoniac by acetic acid.

albumin of chyle contains a larger amount of alkali than that of blood; it is dered turbid, even by very great dilution with water; when boiled, it forms, erent flocks, but a milk-white opaque liquid; on evaporation, colourless films n the surface. The aqueous extract of the chyle-residue has a strong alkaline n; on neutralising it with acetic acid, a turbidity is produced, which afterwards lves; on subsequently adding ferrocyanide of potassium, a copious precipitate is . The original aqueous extract becomes strongly turbid by boiling with sal- iac, also on addition of nitric acid. From chyle-albumin exhausted with water, , and ether, Lehmann obtained 2·068 per cent. of ash, containing a considerable y of alkaline salt which effervesced with acids.

fat of chyle is mostly unsaponified in the smaller lacteals, saponified in the c duct. Chyle does not appear to contain any crystallisable fat.

existence of *sugar* in chyle is doubtful; that of *bile-constituents*, though pro- has not been demonstrated. *Lactic acid* was found by Lehmann in the chyle of rses, one of which had been fed two hours before death, with oats, the other with

e is very rich in *alkalis*, combined partly with albumin, partly with lactic and acids; hence the aqueous solution of the ash has a strong alkaline reaction, fervesces with acids. *Sulphates of the alkali-metals* are found in the ash, but the chyle itself. *Sulphocyanides* are not found. Alkaline phosphates occur in uantity only, even after the digestion of vegetable food. The *chlorides of sodium tassium* occur in large quantity.

is found in the serum of chyle, but its presence may be due to admixed blood-

ng fasting or scanty nutrition, the chyle is poorer in solid constituents, espe- at, and consequently has a turbid but not a milky appearance.

l rich in fat, whether animal or vegetable, increases the quantity of fat in the

he contents of the thoracic duct, two hours after death, of a man killed by ng, Rees found 98·48 per cent. water, 7·08 albumin, with traces of fibrin, 0·56 s extract, 0·5 alcoholic extract, 0·44 chloride, carbonate, and sulphate of potas- vith traces of phosphate of potassium and oxide of iron, and 0·92 fatty matters. mon has given the following analyses of the chyle of three horses, the first fed , the other two on oats:

	I.	II.	III.
Water	949·670	928·000	916·000
Fat	1·186	10·010	0·900
Albumin	42·717	46·430	60·530
Fibrin	0·440	0·805	0·900
Hematosin	0·474	trace	5·691
Extractive matter and ptyalin	8·360	5·320	5·265
Chloride and lactate of sodium with traces of calcium-salts	—	7·300	6·700
Sulphate and phosphate of calcium with traces of oxide of iron	—	1·100	0·850
	1002·847	998·965	996·836

The first of these analyses does not, however, admit of direct comparison with the others, as it evidently applies to the organic matter alone.

In the chyle of a cat, Nasse found in 1000 pts.: 905·7 water, and 94·3 solid matter, consisting of 1·3 fibrin, 32·7 fatty matter, 48·9 albumin, globules resembling those of the blood, and extractive matter, 7·1 chloride of sodium, 2·3 other soluble salts, trace of iron, and 2·0 earthy salts.

CHYME. This name, now but little used, was applied to the products of digestion contained in the small intestines, before they have been submitted to the action of the bile and pancreatic juice.

CHYMOSIN. A peculiar nitrogenous matter existing in the gastric juice (*q. v.*); also called *pepsin* or *gasterase*.

CHYTOPHYLLITE. A name applied by Hausmann to certain slags from blast-furnaces, having a broadly laminar structure. They are mainly ferrous silicates, $2FeO.3SiO^2$, the iron being partly replaced by calcium and the silica by alumina. (Jahresber. f. Chem. 1850, pp. 26, 710; 1851, p. 768; 1856, p. 842.)

CHYTOSTILBITE. Radiate blast-furnace slags, having the composition of augite, M^2SiO^3 or $M^2O.SiO^2$, the silica being partly replaced by alumina. (Hausmann, Jahresb. f. Chem. 1856, p. 843.)

CIBOTIUM CUMINGII. An East Indian fern, the hairy stem of which is much used as a means of arresting hæmorrhage. It contains wax, resin, tannic acid, crenic acid, &c. (v. Bemmelen, Viertelj. pr. Pharm. v. 321.)

CICER ARIETINUM. The *Chickpea.*—The hairs of the stem, leaves and other parts of this plant exude an acid liquid, containing oxalic, acetic, and perhaps malic acid, and, according to Dispan, another acid peculiar to the plant.

CICHORIUM ENDIVIA. See ENDIVE.

CICHORIUM INTYBUS. *Chicory.*—The root of this plant is extensively used for mixing with coffee. The following table exhibits the composition of the organic part of the wild and cultivated varieties, as determined by v. Bibra:

	Cultivated.	Wild.
Fat, insoluble in alcohol	0·07	0·47
Resin	0·84	0·96
Organic acid, precipitable only by subacetate of lead	1·01	1·18
Organic acid, precipitable also by the neutral acetate	2·54	2·51
Sugar	22·08	37·81
Inulin	19·12	10·90
Albumin	0·12	0·15
Tannic acid and volatile oil	trace	trace
Woody fibre	54·21	46·00
	99·99	99·98

The chief difference in the composition of the two varieties appears to be in the relative proportions of inulin and sugar.

Anderson (Highland Agric. Soc. Journ. 1853, p. 61) found in a specimen of chicory cultivated in Yorkshire, 1·6 per cent. nitrogen and 3·6 ash; in another, from the neighbourhood of Glasgow, 1·5 per cent. nitrogen and 6·7 ash.

The leaves contain in 100 pts. 90·9 water and 1·42 ash. (Anderson.)

The composition of the ash of the root and leaves of chicory, as determined by Anderson (*loc. cit.*), and by Graham, Stenhouse, and Campbell (Chem. Soc. Qu. J. ix. 45), is as follows:

Composition of Chicory-Ash *in* 100 pts.

	Root.						Leaves.
	Anderson.		Graham, Stenhouse, and Campbell.				Anderson.
	Scotch.	Yorkshire.	Darkest English (Yorkshire.)	English.	Foreign.	Guernsey.	
	34·6	55·2	37·07	27·13	40·20	41·41	46·6
	8·9	—	8·99	16·46	2·77	4·92	—
	10·1	7·9	10·38	10·53	6·79	6·85	11·3
a	6·7	4·1	5·83	7·87	4·66	4·97	2·6
xide	0·8	1·0	4·22	3·41	7·24	4·55	1·0
	4·4	1·3	3·81	2·61	12·75	10·52	0·8
ic acid (an-e)	15·2	6·2	10·95	11·48	7·32	7·76	7·1
ric acid (an-e)	16·2	13·0	11·81	12·29	9·60	8·59	7·1
of potassium	—	2·3	—	—	—	—	1·6
sodium	3·0	8·8	—	—	—	—	1·1
e	—	—	5·46	5·10	4·39	5·89	—
c acid (anhy-	—	—	1·97	3·14	3·81	4·12	20·5
	99·9	99·8	100·49	100·02	99·53	99·58	99·7

n chicory-root is roasted, several volatile products are given off, and on con-g them, a yellowish liquid is obtained, which has a sharp unpleasant odour, the skin permanently dark brown, and contains tannic acid. The aqueous n of the roasted chicory contains sugar, a bitter substance, empyreumatic oil, nces which exert a strong reducing action on gold and silver-salts, and organic precipitable by lead-salts. It has a disagreeable taste, and, if taken in con-ble quantity, produces nausea and sometimes giddiness. (Handw. d. Chem. 24.)

UTINE. An alkaloïd but little known, said to exist in the water-hemlock, *virosa.* (Polex, Arch. Pharm. xviii. 174. — Wittstein, Buchner's Repert. 19.)

DER. A fermented liquor prepared from apples. Large quantities of it are in Herefordshire, Devonshire, and the adjoining counties; in the counties of ford and Cork in Ireland; in Normandy and Picardy in France; in Belgium; in ny; and in many parts of the United States.

apples used in the preparation of cider, ripen at different seasons; in this y, the earliest begin to fall from the trees at the end of September, but the ma-do not attain their maturity till about the end of November or the beginning of ber.

make good cider, it is necessary that the apples be quite ripe, to ensure which, it omary to leave them to ripen for a month or more after gathering; they must wever, be allowed to get over-ripe, otherwise the quantity of sugar will diminish. verage proportion of sugar in apples at different stages of maturity, has been to be as follows:

Unripe.	Ripe.	Over-ripe.
4·90	11·00	7·95

make cider, the apples are thrown into a circular stone trough, usually about n diameter, called the *chase*, round which the *runner*, a heavy circular stone, is by one or sometimes by two horses; the pulpy fruit or "mist" is then enclosed rse hair-cloths, and subjected to pressure by a screw-press, and the brown juice exudes is poured into casks placed either out of doors, or in sheds where there is current of air. Sometimes the dry residue which remains in the bags, is mixed water, ground again, and the liquor pressed out as before. This latter product what is called "water-cider," a thin unpalatable liquor which is given to the ers early in the year.

ut three or four days after the juice has been transferred to the casks, it begins ment, the thick heavier parts then subsiding to the bottom, while the lighter e clear bright cider. This is then racked off into another cask, and the sediment to strain through linen bags, the liquid which oozes through being restored.

fermentation is the most delicate part of the process; *slight* fermentation leaves uor thick and unpalatable; *rapid* fermentation impairs its strength and durability; *cessive* fermentation makes it sour, harsh, and thin. Other things being equal, der will probably prove the best in which the vinous fermentation has proceeded slowly, and has not been allowed to pass into the acetous. If the cider does not clear spontaneously, finings, such as isinglass, eggs, or blood, are added, as in the preparation of beer.

At the beginning of January, the cider is moved into cellars, where, by large growers, it is frequently stored in casks of great capacity, containing 1000, 1500, or even 2000 gallons. In March, the liquor is bunged down; it is then fit for sale, and may be used soon afterwards, though it will greatly improve by keeping. For bottled or effervescing cider, the liquor should be bottled or wired down in the September or October after it is made; some persons prefer an earlier time, the end of April or the beginning of May. A more effervescent liquid is thus obtained, but considerable loss occurs from the bursting of bottles. (*Penny Cyclopædia.*)

The strongest cider contains in 100 volumes, 9·87 volumes of alcohol of 92 per cent.; the weakest, 5·21 volumes. (Brande.)

CIMICIC ACID. $C^{15}H^{28}O^{2} = \left.\begin{matrix}C^{15}H^{27}O\\H\end{matrix}\right\}O$. (Carius, Ann. Ch. Pharm. cxiv. 147.)—An acid, belonging to the oleic series, contained in the fetid oily liquid ejected by a kind of bug (*Rhaphigaster punctipennis*) when irritated. To prepare it, the insects are treated with strong alcohol, which extracts a brown resinous substance, then macerated with cold ether. The solution thus obtained, yields the acid by evaporation, as a coloured mass; it is purified by converting it into a barium-salt, washing with water and with dilute alcohol, then decomposing the salt with hydrochloric acid, and drying the resulting fat between 40° and 50° C. Two or three hundred of the insects yield about 12 grms. of the fatty acid: the insects freed from fat and dried, weighed 23 grms.

Cimicic acid is a yellow crystalline mass, having a peculiar rancid odour: lighter than water and insoluble therein; very little soluble in alcohol, easily in ether, from which it crystallises by slow evaporation in stellate groups of colourless needles. It melts at 44° C., and, when subjected to dry distillation, yields, besides gases, an oil which solidifies on cooling, and appears to contain some undecomposed acid.

Cimicic acid, treated with *pentachloride of phosphorus*, gives off hydrochloric acid gas, and forms a liquid which, when shaken up with cold water, yields chloride of cimicyl, $C^{15}H^{27}O.Cl$, as a heavy oil, which solidifies at about 44° C., does not crystallise distinctly; dissolves in ether without alteration, is immediately decomposed by alcohol into cimicic ether and hydrochloric acid; and by potash into cimicate and chloride of potassium.

Cimicic acid in alcoholic solution is strongly acid. It dissolves easily, with aid of heat, in aqueous alkalis.

The *cimicates* have the composition $C^{15}H^{27}MO^{2}$. Those of the alkali-metals dissolve in a small quantity of water, but a larger quantity renders the solutions opalescent; they froth with soap-solution, and are precipitated from their aqueous solutions by excess of alkali and by chloride of sodium. The cimicates of the earth-metals and heavy metals are nearly or quite insoluble in water and alcohol; the *lead-salt* only appears to be slightly soluble in ether. The *silver-salt* blackens quickly when exposed to light.

Cimicate of Ethyl, $C^{15}H^{2}(C^{27}H^{5})O^{2}$, obtained by treating chloride of cimicyl with with alcohol and precipitating by water, is a light yellow oil, smelling like the free acid, but stronger: it is lighter than water; does not solidify at 0° C; dissolves readily in alcohol; turns brown when heated.

CIMMOL. Syn. with HYDRIDE OF CINNAMYL (p. 988).

CIMMYL. Löwig's name for the radicle $C^{9}H^{7}$, which he supposes to exist in cinnamic acid.

CIMOLITE or **CIMOLIAN EARTH,** the *cimolia* of Pliny, which was used by the ancients both medicinally and for cleaning cloths, and which has been confounded with fuller's earth and tobacco-pipe clay, is found in the island of Argentiera, the ancient Cimolus, also in Bohemia and in Russia. It is of a light greyish-white colour, acquiring superficially a reddish tint by exposure to the air; massive; of an earthy, uneven, more or less slaty fracture; opaque when shaved with a knife, smooth, and of a greasy lustre; tenacious, so as not without difficulty to be powdered or broken; and adhering pretty firmly to the tongue. Its specific gravity is 2·18—2·30. It is immediately penetrated by water, and splits into thin laminæ of a curved slaty form. Triturated with water, it forms a pappy mass; and 100 grains will give to three ounces of water the appearance and consistence of a thickish cream. If left to dry after being thus ground, it detaches itself in hard bands, somewhat flexible, and still more difficult to pulverise than before.

When it is ground with water, and applied to silk or woollen fabrics greased with oil of almonds, the oil is completely discharged by a slight washing in water, after the stuffs en hung up a day to dry, without the least injury to the beauty of the colour. l used by the natives of Argentiera for the same purposes as of old.

ollowing are analyses of cimolite:—*a.* From Argentiera, by Klaproth:— Alexandrowski in Russia, by Ilimoff:—*c.* A pseudomorph of augite (also *iauxite*), from the decomposed basalt of Bilin, Bohemia, by Rammelsberg:— called *pelikanite*, from the decomposed granite of Kiew in Russia, by Oucha- *Rammelsberg's Mineralchemie*, p. 583.)

O^2	Al^2O^3	Fe^2O^3	$Ca''O$	$Mg''O$	K^1O	P^2O^5	H^2O	
·00	23·00	1·25	—	—	—	—	12·00	= 99·25
·52	23·55	—	—	—	—	—	12·00	= 99·07
·30	24·23	—	0·83	—	—	—	12·34	= 99·70
·66	22·84	0·44	—	0·56	0·30	0·17	9·31	= 99·28

rst three analyses agree nearly with the formula $2Al^2O^3.9SiO^2 + 6aq.$, which is f a sesquisilicate, and reducible to $2alO.3SiO^2 + 2aq.$ or $al^2SiO^4.SiO^2 + 2aq.$; the contains the same proportions of silica and alumina, but only 4 at. water, $^3.9SiO^2 + 4aq.$

olite appears to be formed from augite containing alumina and magnesia, by the of infiltrating waters containing carbonic acid, which carry away the magnesia, a hydrous silicate of aluminium; an addition of alumina may probably take hrough the accompanying decomposition of associated felspar. (Dana, ii. 164.)

IACROL. A product of the action of iodine on wormseed oil (*q. v.*)

ÆBENE and **CINÆBENE-CAMPHOR.** Constituents of wormseed-oil, ing to Hirzel.

ÆPHANE, CINÆPHENE, CINÆPHONE. Products obtained, according Hirzel, by the action of iodine on wormseed-oil (*q. v.*)

NCHONA BARK. *Cortex Chinæ, C. Peruvianus, Quinquina, Cascarilla.*— ame is applied to the bark of the stem and branches of various species of *Cin-* and other genera of the order *Rubiaceæ*, sub-order *Cinchoneæ*. Those which are ed from trees of the genus *Cinchona*, are called true cinchona barks; they n quinine and cinchonine, and have long been known for their antifebrile pro- s; the barks of the other genera of the sub-order above-mentioned, chiefly *bergia* and *Exostemma*, are called false cinchona barks; they contain certain nate principles, likewise found in the true cinchona barks, namely quinic acid, vic acid, quinotannic acid, and cinchona-red, but no alkaloïds.

e antifebrile barks were first introduced into Europe from Peru, about the year by the Countess of Chinchon, wife of the Viceroy of Peru (in whose honour the *Cinchona* was given to the genus by Linnæus), and a few years later by the ts, and soon acquired great celebrity for the cure of intermittent fevers, being n by the names *Pulvis Comitissæ, Jesuiticus, Cardinalis, Patrum.* The trees n yield them were first recognised and described, about a century later, by the ch astronomer La Condamine, in his journey in Peru.

e true cinchonas grow on the wooded slopes of the Cordilleras, from western zuela to northern Bolivia, between 10° N. and 19° S. latitude, in a narrow zone ding through a vertical height of about 6400 feet. The barks which are richest kaloïds, and are exported (*Cascarillo's fino's*), occur most abundantly from 7° N. ° S. latitude, and as they require a cool moist climate, they occupy the region 11,150 to 6400 feet above the sea-level, whilst those which contain smaller tities of the alkaloïds, and are therefore not fit for exportation, occupy a warmer drier zone, between 6400 and 4800 feet in vertical height. With these also are l the *Ladenbergias*, which produce false cinchona barks; they extend also 2000 ower through the tropical part of the continent. The *Exostemmas*, which also ice false cinchona barks, inhabit only the hot zone, and are found not only on ontinent, but on the islands. Since 1853, the most highly prized cinchonas have successfully cultivated in Java. The cultivation has also been attempted in ria and in India.

e collection of the bark takes place in New Granada at all times of the year; eru and Bolivia, only in the dry season. The inner bark of the stems and larger ches, after having been freed from the outer bark, is very carefully dried over a for three or four weeks, the weight of the dried products being about one-third of of the fresh bark. According to Karsten, a tree 60 feet high and 5 feet in eter, yields about 10 cwt. of dry bark; but such specimens are not often met with. Ecuador and northern Peru, the bark is taken chiefly from the branches; in hern Peru and Bolivia, from both stems and branches; it is dried in the sun, either in the forest itself, or in drier situations lower down the hill-side. According to Pasteur, the process of drying in the sun is injurious.

The **TRUE CINCHONA BARKS** known in commerce, are of three kinds, *grey* or *brown*, *yellow*, and *red*. They come to market either in rolled quills, or in flat or hollowed oblong pieces of very various dimensions. They have a more or less splintery-fibrous texture, contain the cinchona alkaloïds, quinine, cinchonine, quinidine, &c., and when coarsely powdered and heated in a test-tube, give off a red tar.

a. Grey Cinchona-barks. *China fusca* s. *grisea.*—These barks are obtained from the branches, and have therefore the form of quills; they are whitish on the outside, with spots of grey, greyish-brown or brown, sometimes black, fine-fissured, of even fracture, splintery only on the inner surface, and contain more cinchonine than quinine. Five species are enumerated, namely, *Huanoco, Loxa, Pseudoloxa, Huamalies*, and *pale Jaen bark.*

b. Yellow or Orange-yellow barks. *Cinchona flava* s. *aurantiaca.*—These barks are obtained from the stems and larger branches, and consist wholly or nearly so of the bass or inner bark; hence they have a fibrous or splintery texture. The alkaloïds contained in them are chiefly quinine and quinidine. The most important species is the Royal, King's or Calisaya bark, of which there are three varieties, viz.—1. Fine Calisaya bark, from *C. Calisaya*, which occurs either in quills or rolls, of 1 to 1½ inches diameter, partly covered with the outer bark, and is then called *Cinchona Calisaya tecta* s. *convoluta;* or in flat plates destitute of outer bark; *C. Calisaya nuda* s. *plana;* this last variety is the richest of all the barks in alkaloïds.—2. *C. Calisaya morada*, from *C. Boliviana;* and 3. *C. Calisaya fibrosa* s. *scrobiculata.* There are four other species of yellow bark, viz. *Cusco bark* (Weddell); *Carthagena* or *Bogota bark*, also called *Cinchona flava fibrosa; Cinchona flava dura;* and *Cinchona Pitaya.*

c. Red Barks. *Cinchona rubra.*—These barks are obtained from the stems and larger branches; they are mostly of brown-red colour, with proportionately thick outer bark, and strong fibrous or splintery bass. They contain more quinine than cinchonine. The species are *Cinchona rubra suberosa*, from *C. succirubra* and *C. rubra dura.*

FALSE CINCHONA BARKS are derived chiefly from trees of the genera *Ladenbergia* and *Exostemma.* They occur in rolls, half rolls, or flat pieces, having a pre-eminently corky texture. They contain no cinchona alkaloïds, and when coarsely pulverised and heated in a test-tube, yield nothing but a dirty yellow or brown tar. The species are: 1. *Cinchona de Para*, obtained from a *Ladenbergia.*—2. *Cinchona nova Granatensis*, from *Ladenbergia oblongifolia* or *magnifolia.* Pelletier and Caventou found in it quinovic acid and an alkaloïd; Winckler found quinovic acid and cinchona-bitter; Hlasiwetz found quinic acid, quinovic acid, quino-tannic acid, and cinchona-red.—3. *Cinchona nova Brasiliensis*, from *Ladenbergia Riedelana*, said to contain quinic and quinovic acids.—4. *Cinchona alba Granatensis*, from *L. macrocarpa*, said to contain alkaloïds, but the statement is doubtful.—5. *Cinchona bicolorata* s. *Atacamez*, s. *Pitoya*, said to contain an alkaloïd pitoyine.—6. *Cinchona Caribæa*, from *Exostemma Caribæum*, contains quinovic acid.—7. *Cinchona Sta. Lucia*, s. *Piton*, s. *Martinicensis*, from *Exostemma floribundum.*

The organic constituents of cinchona barks, are quinine, cinchonine, and two or three isomeric modifications of those bases; aricine; quinic, quinovic and quinotannic acids; cinchona-red; a yellow colouring matter; a green fatty matter; a small quantity of volatile oil, having the odour of the bark; together with starch, gum, and woody fibre.

The ash of cinchona barks consists chiefly of carbonate of lime, and varies in quantity from 0·58 per cent. (in Calisaya bark), to 3·4 (in ash-bark or pale Jaen bark). The acids of the bark are neutralised, partly by the lime, partly by the alkaloïds, and accordingly analysis appears to show that the lime diminishes in proportion as the bark is richer in alkaloïds. Some barks, *e.g.* Calisaya and Huanoco, yield ashes of a green colour, arising from manganate of potassium (Puttfarcken, Pharm. J. Trans. xi. 129). Reichel found in the ash of various cinchona barks, potash, lime, magnesia, silica, and sulphuric acid, with smaller quantities of alumina, iron, manganese, phosphoric acid, and chlorine.

The first chemical examination of cinchona bark appears to have been made in 1785 by Hermbstädt, who obtained from it the calcium-salt of quinic acid, which he designated as *essential salt of quinine.* Schneider in 1807 and Vanquelin in 1808, separated quinic acid from the calcium-salt. Quinotannic acid was discovered by Deyeux in 1793, and obtained in more definite form by Séguin, in 1797. Cinchona-bitter and cinchona-red were obtained from red cinchona bark by Reuss in 1810. At this time, ten years before the discovery of the cinchona alkaloïds, Berzelius made a quantitative examination of a yellowish-brown cinchona bark, and found in it 0·5 per cent. of green soft resin, which quickly hardened, 7·35 quinotannic acid, 6·87 bitter syrupy extract (this contained the alkaloïds), 2·5 quinate of potassium and quinate of calcium, coloured by a small quantity of extractive deposit, 1·25 extractive deposit dissolved out by carbonate of potassium, 2·70 amylaceous gum and 73·75 woody fibre.

Cinchonine appears to have been obtained in an impure state by Gomes of Lisbon in 1811; but its true nature remained unknown till 1820, when Houton-Labillardière first drew attention to the alkaline reaction of the substance obtained by Gomez, and communicated his observations to Pelletier and Caventou, who, in the same year, succeeded in isolating, first cinchonine, and afterwards quinine, and in proving them to be true vegetable alkaloïds. Several isomeric modifications of these alkaloïds were afterwards discovered and variously named; but according to Pasteur (Compt. rend. xxxvi. 26; xxxvii. 110), whose results appear to be the most exact, their number may be reduced to four, namely, cinchonicine and cinchonidine isomeric with cinchonine; quinicine and quinidine isomeric with quinine. Cinchonicine and quinicine are produced by the action of heat on cinchonine and quinine respectively; cinchonidine is found in certain cinchona barks, namely, Huamalies, Maracaibo, and Bogota barks, and quinidine is obtained from the mother-liquors of the manufacture of sulphate of quinine.

The three isomeric bases of each group are distinguished by their optical rotatory power. (See the several Alkaloïds.)

Aricine was discovered in 1829 by Pelletier and Corriol (J. Pharm. xv. 575), in a white cinchona bark, from Arica. Elaborate examinations of various cinchona barks, were published by Reichardt in 1855, and by Reichel in 1856; and lastly, in 1860, De Vry published his researches (*Bonplandia*, viii. 270), on the *Cinchona Calysaya* cultivated in Java.

Cinchona barks are employed medicinally in the form of tinctures and infusions, and were used in this manner, for their febrifuge and tonic properties, long before the discovery of the alkaloïds; but as these qualities are likewise possessed by the pure alkaloïds, and the administration of these alkaloïds is, in many cases, much more convenient than that of the bark in substance, the alkaloïds, especially quinine in the form of sulphate, are prepared from the barks on a very large scale;—the value of a bark to the manufacturer may indeed be said to depend on the quantity of sulphate of quinine that it will yield. It is found, however, that the medicinal properties of the barks are due to the quinic and other acids which they contain, as well as to the alkaloïds, and consequently that the bark in substance cannot in all cases be advantageously replaced by the pure alkaloïd. At one time indeed it was supposed that the medicinal efficacy of the barks depended chiefly on the tannin contained in them. Berzelius wrote in 1831 (*Traité de Chimie*, Paris, v. 587): "There is a law in Sweden in virtue of which, every cinchona bark imported into the country must be tested with infusion of galls, ferric sulphate, solution of gelatin, and tartar emetic; and it is proved, by an experience of sixteen years, that the most efficacious bark is that which gives the strongest precipitate with solution of gelatin and tartar-emetic, in other words, which contains most tannin." The barks which appear to be best adapted for medicinal use are, the flat Calisaya and the Huanoco barks, the former containing the largest proportion of quinine and quinotannic acid, while the latter is richest in cinchonine and quinic acid.

Reactions of Cinchona Barks.—The aqueous infusion of these barks contains the alkaloïds in combination with quinic and the other acids,—and as these salts, and likewise the starch, are more soluble in hot than in cold water, the liquid always becomes turbid on cooling. To extract the whole of the bases, it is necessary to acidulate with hydrochloric or sulphuric acid.

The solution thus obtained may be tested:

1. For alkaloïds, which, if present, will give a white precipitate with *tannic acid*, and a yellow crystalline precipitate with *dichloride* of platinum. Another mode of testing for the alkaloïds, is to precipitate the acid solution with carbonate of sodium and distil the precipitate with excess of caustic alkali, whereby a distillate of chinoline (p. 869) will be obtained.

2. For Quino-tannic acid.—White precipitate with *solution of gelatin*; green with *ferric salts*; dirty white with *tartar-emetic.*

3. For Quinovic acid.—If this acid is present, *sulphate of copper* first colours the liquid green and then throws down a precipitate, which when collected and washed, has a bitter metallic taste. Winckler proposes to estimate the relative value of cinchona barks by the amount of quinovic acid thus precipitated, inasmuch as the bitterness of a bark depends partly (and in the case of the false barks, exclusively) on the presence of quinovic acid.

4. For Quinic acid.—This acid distilled with *sulphuric acid and peroxide of man-*

ganese, yields a distillate of quinone, which is a yellow crystallisable substance, having a pungent odour, and soluble in water. The aqueous solution mixed with ammonia, absorbs oxygen from the air, and assumes, first a brown, then a black colour; a reaction which will indicate the presence of very small quantities of quinic acid. Chlorine-water changes the colour of the aqueous solution of quinone from yellow to bright green. The formation of quinone in this manner is proposed by Stenhouse (Mem. Chem. Soc. ii. 226), as a means of distinguishing between true and false cinchona barks, the former alone containing quinic acid. According to other authorities, however (p. 964), this acid is likewise present in some of the false cinchonas.

For the *quantitative estimation* of the alkaloïds, the following methods may be used.

1. One drachm of the finely powdered bark is to be boiled for a few minutes with an ounce of water and half a drachm of strong acetic acid; the liquid filtered off, the residue boiled with a little dilute acetic acid; the liquid again filtered off, and the powder washed; the whole of the liquid evaporated to dryness on a water-bath; and the extract dissolved in a little water and again evaporated, to expel all the free acetic acid. The residue is then to be treated with absolute alcohol and blood-charcoal; the colourless solution filtered off, and the residue exhausted with alcohol. To this solution a few drops of hydrochloric acid are to be added, and next a solution of chloride of platinum as long as it causes turbidity; and the precipitate of chloroplatinate of quinine and cinchonine transferred to a weighed filter, washed with alcohol, dried and weighed. The platinum-salt of quinine contains 44·3 per cent. of that base; the cinchonine-salt 43 per cent. of cinchonine: hence the proportion of the two alkaloïds may be found by the method of indirect analysis (p. 224) (Duflos). The alkaloïds might also be precipitated by tannic acid and infusion of gall-nuts.

2. Fifty grains of the pulverised bark is treated with a little diluted hydrochloric acid; the liquid filtered, and the residue washed with a mixture of alcohol and a few drops of the same acid. The dark brown solution is then mixed with a little powder of hydrate of lime, so as nearly to decolorise it, and the precipitate, being thrown on a filter, is washed with alcohol. The liquid contains the organic bases in the free state. It is to be neutralised with hydrochloric acid, diluted with water, and freed from alcohol by evaporation. When it is reduced to two or three drachms measure, the bases are to be thrown down with solution of caustic ammonia; and the precipitate is to be filtered, washed with cold water, dried, and weighed. By digesting it with ether, the quinine is dissolved, and the cinchonine remains behind.

As the alcoholic solution of the bases thrown down by the alkali is often rather strongly coloured, and requires to be decolorised by animal charcoal, alum, protochloride of tin, or hydrate of lead, which occasions loss, Thibouwery extracts the alkaloïds from the precipitate by oil of turpentine, or other non-oxygenated oil, and Rabourdin effects the solution by means of chloroform. The same object is attained, according to Badollier and Scharlan, by subjecting the bark, before treating it with acidulated water, to the action of dilute potash, which removes the tannic acid and the cinchona-red.

3. A quarter of a pound of the coarsely powdered bark is boiled for half an hour with very dilute hydrochloric acid; this operation is repeated on the filtered residue; the final residue is washed with water; the whole of the liquors evaporated to dryness over the water-bath; and the extract redissolved in faintly acidulated water, on the bath. Much of the cinchona-red will remain undissolved. The filtrate is to be concentrated to a small bulk, its bases precipitated by ammonia, and the mixture drained and washed with cold water on a weighed filter. The quinine and cinchonine may then be separated and determined, as above, by means of ether.

4. An ounce of the pulverised bark is digested with five ounces of water containing hydrochloric acid (1½ drachm of acid to a pint of water); the extract is pressed through linen, the operation being repeated three times with each four ounces of the acidulated water; the extracts are then evaporated on the water-bath to six ounces, and the residue washed. From this solution, the alkaloïds are precipitated by soda-ley, till an alkaline reaction is produced; the liquid is then supersaturated with acetic acid; and after the cinchona-red has separated, the nearly limpid liquid is to be filtered. The filtrate is again precipitated with soda-ley; the precipitate left to settle for a day; the clear liquid decanted; the precipitate collected on a small filter, and left to drain well; the still moist filter, with the precipitate, repeatedly shaken up with chloroform; the clear chloroform containing the alkaloïds poured into a tared capsule; the operation repeated three times, with fresh chloroform; and the liquid left to evaporate in the capsule: the net weight gives the total amount of the alkaloïds. The quinine may then be completely dissolved out by ether, the residue in the capsule consisting wholly of cinchonine, which may be weighed. In this manner the relative quantities of the two bases are determined.

A crystalline deposit in the amber-like mass of quinine, indicates the presence of alkaloïds. To separate cinchonidine (Pasteur's, p. 965), dissolve 1 gramme ass in 15 drops of dilute sulphuric acid and 24 drops of water, then add 20 ether and 30 drops of ammonia: the quinine will then dissolve, leaving the line, provided the quantity of the latter is not less than 10 per cent. Smaller s may be separated by means of ether already saturated with cinchonidine, ill still dissolve quinine. (Zimmer.)

line may be separated from quinine by the greater solubility of its oxalate in er; on treating a solution of quinine with oxalate of ammonium, the quinine wholly precipitated as oxalate, whilst the quinidine-salt remains dissolved.

llowing table (p. 968) exhibits the proportions of the alkaloïds contained in difchona-barks. The determinations must not however be regarded as very exact, cause the barks known in commerce by the several names in the table are nixtures of different sorts, partly also because different methods of analysis e different results. According to Wittstock, the precipitation of the bases acid extract of the bark by alkalis, is not complete, inasmuch as a somewhat ble precipitate may afterwards be obtained with tannic acid. Moreover, the tes which contain the colouring matter always retain a certain portion of the , and charcoal, if used to decolorise the extract, carries down nearly the whole ses; lastly, the separation of quinine from cinchonine by ether is by no means .

rdt has determined the whole of the constituents of various cinchona-barks. wing is an extract from his table:

Composition of CINCHONA-BARKS.

	Cinchona flava fibrosa.	*Cinchona rubra.*	*Cinchona Huanoco.*	*Cinchona Calisaya plana.*	*Cinchona Calisaya convoluta.*
. . . .	0·705	0·955	0·854	2·701	0·659
ine	0·245	0·389	2·240	0·264	0·327
a	0·266	0·100	0·086	0·137	0·123
cid	6·730	6·019	8·985	6·944	7·245
acid	0·196	0·222	1·736	0·684	0·679
nnic acid	0·964	3·179	0·515	3·362	2·162
a-red	0·933	4·384	—	0·722	0·705
cid	7·729	9·933	27·088	16·355	27·345
e	59·146	47·777	25·479	45·522	32·653
organic constituents .	77·604	74·221	68·514	77·968	72·777
c constituents . . .	1·634	1·661	2·513	1·224	1·650

e bark of *Cinchona Calisaya*, cultivated in Java, De Vry found ordinary crystallisable quinine, quinidine, cinchonine, and quinovic acid. The stems found to contain 3·90 per cent. of quinine and quinidine; the root-bark the crude alkaloïds; the root-wood 0·06, chiefly cinchonine; the stem-wood inine and cinchonine; the young branches scarcely a trace of alkaloïds; the one. Quinovic acid was found more abundantly in the wood than in the bark; est quantity in the root-wood, and least in the leaves. The bark of *Cinchona folia?* yielded only 0·4 per cent. of crude alkaloïds. (Handw. d. Chem. ii. [2] 971.)

CHONA-RED. A constituent of cinchona bark, produced from quinocid by atmospheric oxidation. It may be extracted by boiling the bark with reating the residue with ammonia, and precipitating the ammoniacal filtrate drochloric acid, washing the resulting precipitate of quinovic acid and cinchonaboiling it with thin milk of lime: quinovate of calcium then dissolves, and a-red remains undissolved in combination with lime. The residue, after being with water, is treated with hydrochloric acid; then washed again, dissolved in a, and reprecipitated by hydrochloric acid; dissolved in alcohol, after another h washing; and the filtrate evaporated to dryness over the water-bath. rz, Ann. Ch. Pharm. lxxx. 332.)

ona-red is an amorphous, chocolate-coloured or red-brown, nearly black mass, nsoluble in water, easily soluble, with red-brown colour, in alcohol, ether, and lyes, also in strong acetic acid. It is decomposed by heat, giving off copious es, and yielding by dry distillation, an empyreumatic oil, pyrogallic acid, and re, volatile, carmine-coloured, aromatic substance, insoluble in water, but soluble ol, ether, and alkaline liquids. (Boissenot, J. Pharm. [3] xxv. 199.)

ormula of cinchona-red is $C^{4}H^{7}O^{2.5}$, according to Schwarz; $C^{7}H^{8}O^{4}$ according to ot; it is doubtful whether it has ever been obtained pure. The bark of *Cinncifolia* (Mutis) contains, according to Reichel, from 1 to 2·5 per cent. of it; nchona barks are said to contain a larger amount.

Percentage of ALKALOÏDS *in* CINCHONA BARKS.

Cinchona regia plana.

Quinine.	Cinchonine.	Authority.
1·75	—	v. Santen.
1·26	—	
0·76	0·06	
2·30	0·08	Thiel.
2·19	—	Stratingh.
2·6	—	
2·3	0·12	Wittstock.
3·72	—	Michælis.
1·24	—	Kirst.
2·13	—	Riegel.
3·22	—	
3·3	—	
2·5	—	
2·14	—	Winckler.
1·74	—	Soubeiran.
2·8	—	Henry.
2·70	0·26	Reichardt.
2·23	0·5	Delondre & Bouchardat
2·34	0·66	

Cinchona Quito flava.

Quinine.	Cinchonine.	Authority.
0·8	2·5	Delondre.

Cinchona regia convoluta.

Quinine.	Cinchonine.	Authority.
0·12	—	v. Santen.
0·68	—	
1·83	0·03	
0·91	0·26	
0·35	—	
2·01	—	Michælis.
2·13	—	Soubeiran.
1·09	—	Kirst & Göbel.
0·78	—	
1·1	0·66	Delondre & Bouchardat
1·5	0·82	
0·69	0·33	Reichardt.

Cinchona flava dura.

Quinine.	Cinchonine.	Authority.
0·03	0·17	Winckler.
0·73	0·56	Kirst.
0·42	0·4	v. Santen.
1·0	0·8	Geiger.

Cinchona Pitaya.

Quinine.	Cinchonine.	Authority.
1·5	0·82	Delondre & Bouchardat
1·86	0·99	

Cinchona rubra.

Quinine.	Cinchonine.	Authority.
1·7	0·8	Pell. & Cav.
0·88	0·91	v. Santen.
0·35	1·26	
0·12	1·95	
0·17	1·17	
0·34	1·04	
0·10	2·39	
0·08	0·26	
0·83	0·41	Michælis.
0·52	0·84	Winckler.
0·10	2·34	
0·08	1·04	
2·65	1·54	Riegel.
0·52	0·73	
2·84	1·3	Duflos.
1·66	1·08	Henry.
1·5	0·82	Delondre & Bouchardat.
1·8	0·99	
1·12	0·4	
1·34	0·5	
0·95	0·38	Reichardt.

Cinchona flava fibrosa.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
0·12	—	0·36	v. Santen.
0·34	—	0·44	
0·34	—	—	
1·00	—	0·90	Geiger.
0·70	—	—	Kirst.
—	—	1·05	Winckler.
2·72	—	0·31	Bidtel.
1·33	—	2·73	
1·03	—	1·89	
2·23	—	0·25	Delondre & Bouchardat
2·38	—	0·33	
0·38	—	0·63	Pereira.
1·4	1·17	—	
0·34	0·15	0·37	Hindsley.
0·77	0·25	1·26	
0·70	—	0·24	Reichardt.

Cinchona rubiginosa.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
—	—	3·0	Franck.
—	—	3·33	Winckler.
—	—	1·01	

Cinchona Huanoco.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
—	—	0·96	v. Santen.
—	—	2·73	
0·4	—	2·5	Stratingh.
—	—	1·58	Wittstock.
0·42	—	0·65	Michælis.
0·36	—	0·96	
—	—	2·18	Kirst.
—	—	2·47	Winckler.
—	—	1·87	Buchner.
—	—	2·8	Böttcher.
—	—	2·4	Riegel.
—	—	1·87	
0·32	—	1·04	Varenton.
0·4	—	1·85	Henry.
1·3	—	3·4	Duflos.
0·24	0·28	1·28	Howard.
0·85	—	2·24	Reichardt.
0·15	—	0·66	Delondre & Bouchardat
—	—	0·82	

Cinchona Huanoco Plana.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
0·45	—	1·0	Delondre.

Cinchona Loxa.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
—	—	0·36	Buchols.
0·06	—	1·0	Thiel.
0·06	—	0·2	
0·1	—	0·24	Michælis.
0·7	—	—	v. Santen.
0·43	—	0·3	Winckler.
0·6	—	0·5	Delondre.
—	0·57	0·06	Howard.
—	1·05	0·08	

Cinchona Pseudo-Loxa.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
0·4	—	0·28	Howard.
0·5	—	0·9	
0·15	—	0·8	Delondre.

Cinchona Jaen pallida.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
0·05	—	0·21	Geiger.
0·58	—	0·16	Michælis.
1·04	—	0·16	
—	0·61	0·86	Howard.
—	1·2	1·6	

Cinchona Jaen nigricans.

Quinine.	Cinchonidine.	Cinchonine.	Authority.
0·75	0·38	—	Delondre.

Cinchona Huamalies

Quinine.	Cinchonine.	Authority.
0·5	0·85	Thiel.
0·36	0·63	Michælis.
0·16	—	
—	1·2	v. Santen.
0·37	0·5	Kirst.
—	1·67	Hornemann.
—	1·71	
0·3	0·86	Winckler.
—	0·1	
0·08	0·11	

Cinchona Carabaya.

Quinine.	Cinchonine.	Authority.
0·9	0·33	Delondre & Bouchardat
1·34	0·4	

Cinchona Carthagena rosea.

Quinine.	Cinchonine.	Authority.
1·55	0·4	O. Henry.

Cinchona pseudoregia.

Quinine.	Cinchonine.	Authority.
1·01	0·63	Reichel.

Cinchona Maracaibo.

Quinine.	Cinchonine.	Authority.
0·15	0·82	Delondre & Bouchardat
0·22	0·99	

CHONA-TANNIC ACID. Syn. with QUINOTANNIC ACID.

CHONETINE. A product of the decomposition of cinchonine by peroxide
p. 974).

CHONICINE. $C^{20}H^{24}N^2O$. (Pasteur, Compt. rend. xxxvii. 119; Chem.
J. vi. 273.)—An alkaloïd isomeric with cinchonine, and produced from it
he influence of heat. Any salt of cinchonine may be transformed into the
nding cinchonicine-salt by heat; but to make the transformation complete and
decomposition, the heat must be moderate and the salt must be kept for some
a resinous state. The change takes place most easily with the sulphate, which,
ixed with a small quantity of water and sulphuric acid, remains melted at a
derate heat, even after all the water has been expelled, and if kept in this
r three or four hours between 120° and 130° C., is completely converted into
e of cinchonicine. Pasteur is of opinion that the resinous state of the fused
e is essential to the molecular transformation which takes place. The base
separated from the sulphate by precipitation with an alkali.

onicine is nearly insoluble in water, but very soluble in alcohol, whether anhy-
r of ordinary strength. It is very bitter, and is precipitated from its solutions in
n of a liquid resin. It deflects the plane of polarisation to the right. It unites
ith carbonic acid, and separates ammonia from its salts at ordinary temperatures.
sses febrifuge properties. It is distinguished from cinchonidine by its action on
d light, and by not being crystallisable; from cinchonine also by the latter
y, and by its much greater solubility in alcohol, and greater bitterness.

CHONIDINE. $C^{20}H^{24}N^2O$, or $C^{18}H^{22}N^2O$? (Winckler, Repert. Pharm.
iii. 384; xlix. 1.—Leers, Ann. Ch. Pharm. lxxii. 147.—Pasteur, Compt.
xvi. 10; xxxvii. 110; Chem. Soc. Qu. J. vi. 275.—Bussy and Guibourt,
m. [3] xxii. 401.)—This alkaloïd was discovered by Winckler in a bark re-
g the Huamalies cinchona-bark, also in that of Maracaibo. It has likewise
und, accompanied by a small quantity of quinine, in the Bogota cinchona-bark
. According to Pasteur, it is isomeric with cinchonine, ($C^{20}H^{24}N^2O$). The
chemists generally give it the name of *quinidine*.

ration.—Cinchonidine is extracted from the barks by the same processes as
and cinchonine (pp. 966, 971), and purified by crystallising it several times
cohol of 90 per cent., till the solution no longer deposits any resinous matter by
eous evaporation; then reducing the crystals to fine powder; agitating with ether
powder no longer exhibits with chlorine-water and ammonia, the peculiar green
g produced by quinine and quinidine; and finally, recrystallising from alcohol
o Zimmer's method of separation, p. 967.)

rties.—Cinchonidine separates from its alcoholic solution by slow evaporation
drous rhombic prisms, of 94°, hard, with vitreous lustre, and having their faces
triated. The same striæ are observed on the faces which replace the obtuse edges
prism, and the crystals cleave perfectly in the direction of these faces. The
s modified by two brilliant faces, P̆∞ inclined at an angle of 114° 30′, and
on the acute edges. The crystals are easily reduced to a perfectly white pow-
ich becomes electric by friction. They do not taste so bitter as quinine.

onidine is very sparingly soluble in water, 1 pt. of it dissolving in 2180 pts. of
t 17° C., and in 1858 pts. at 100°. It dissolves in 12 pts. of alcohol of sp. gr.
t 17°; ether dissolves but little of it, 100 pts. of the solution containing only
. of cinchonidine. (Leers.)

ution of cinchonidine in absolute alcohol at 13° C., deflects the plane of polari-
f a ray of light strongly to the left; $[\alpha] = -144{\cdot}61°$. (Pasteur.)

ding to the analyses of Leers, cinchonidine contains from 76·40 to 76·88 per
rbon, 7·70—7·81 hydrogen, and 9·99 nitrogen, whence Leers deduced the for-
$^{8}H^{22}N^{2}O$, requiring 76·60 per cent. C, 7·80 H, and 9·93 N, whereas the formula
onine, $C^{20}H^{24}N^2O$, requires 77·9 C, 7·79 H, and 9·09 N. Nevertheless, Pasteur
cinchonidine as isomeric with cinchonine, inasmuch as it is transformed into
icine by heat, without alteration of weight, in the same manner as cinchonine.

npositions.—Cinchonidine melts at 175° C., and solidifies in a crystalline mass
ng. When strongly heated in contact with the air, it burns with a smoky flame,
off an odour like that of bitter-almonds or quinine, and leaving a considerable
y of charcoal. Distilled with hydrate of potassium and a small quantity of
t yields the same mixture of volatile bases as cinchonine (p. 869). When
in fine powder through chlorine-water, it dissolves without perceptible change,
er addition of ammonia.

nercial cinchonidine is often contaminated with quinidine, the presence of
nay be detected either by the green colouring produced by chlorine and am-
or by exposing the recently deposited crystals to the air; the crystals of qui-
hen effloresce without losing their form, assuming a dull white appearance,
e crystals of cinchonidine retain their transparency.

The *Salts of Cinchonidine* are for the most part more soluble in water than those of quinine; they are very soluble in alcohol, but nearly insoluble in ether. The aqueous solution yields with *alkalis* and their *carbonates*, white pulverulent precipitates, which become crystalline when left at rest; and are insoluble in excess of the reagent. With *phosphate of sodium*, *mercuric chloride*, and *nitrate of silver*, they produce white precipitates; light yellow with *chloride of gold*, orange-yellow with *tetrachloride of platinum*, and brown with *chloride of palladium*. With *sulphocyanate of ammonium* they yield a white, and with *tannin* a dirty yellow precipitate.

HYDROCHLORATES OF CINCHONIDINE.—The neutral salt, $C^{20}H^{24}N^{2}O.HCl$ (at 100° C.), forms large rhomboïdal prisms, having a vitreous lustre, soluble in 27 pts. of water at 17° C., very soluble in alcohol, nearly insoluble in ether.

	Analysis (mean).	*Calculation.*	
	Leers.	Leers.	Gerhardt.
	At 100° C.	$C^{18}H^{22}N^{2}O.HCl.aq.$	$C^{20}H^{24}N^{2}O.HCl.$
Carbon . . .	64·34	64·19	69·67
Hydrogen . .	7·17	7·13	6·97
Chlorine . .	10·05	10·54	10·31

The *acid salt*, $C^{20}H^{24}N^{2}O.HCl$ + aq., forms large crystals, very soluble in water and in alcohol; after drying over oil of vitriol, they give off 5·8 per cent. water; the calculated quantity for 1 at. is 5·1, according to Leers' formula; 4·5 according to that proposed by Gerhardt.

	Analysis (mean).	*Calculation.*	
	Leers.	Leers.	Gerhardt.
	At 100° C.	$C^{18}H^{22}N^{2}O.2HCl.$	$C^{20}H^{24}N^{2}O.HCl.$
Carbon . . .	58·30	57·93	63·32
Hydrogen . .	7·12	6·97	6·33
Chlorine . .	18·98	18·99	18·73

Chloromercurate of Cinchonidine, $C^{20}H^{24}N^{2}O.2HCl.HgCl^{2}$, crystallises in shining nacreous scales, sparingly soluble in cold water. Analysis gave 34·77 per cent. C, 4·01 H, 31·9 Hg, and 22·46 Cl, agreeing nearly with $C^{18}H^{22}N^{2}O.2HCl.HgCl^{2}$, which requires 34·52 C, 3·83 H, 31·97 Hg, and 22·63 Cl. The formula $C^{20}H^{24}N^{2}O.2HCl.HgCl^{2}$ would require 35·8 C, 3·51 H, 29·8 Hg, and 21·18 Cl.

The *chloroplatinate*, $2(C^{20}H^{24}N^{2}O.HCl).PtCl^{4}$? is an orange-coloured precipitate, containing at 110° C. from 27·05 to 27·17 per cent. platinum, whence Leers deduces the formula $2(C^{18}H^{22}N^{2}O.HCl).PtCl^{4} = 2aq.$, requiring 27·04 per cent. Pt, whence Gerhardt proposes $2(C^{20}H^{24}N^{2}O.HCl).PtCl^{4}$, which requires 27·36 per cent. It is not probable that the salt should retain 2 at. of water at 110° C.

CHLORATE OF CINCHONIDINE, obtained by decomposing the neutral sulphate with chlorate of potassium, crystallises from alcohol in long silky prisms, grouped in tufts. It melts at a gentle heat, and decomposes with loud explosion at a higher temperature.

HYDROFLUATE OF CINCHONIDINE forms silky needles, very soluble in water.

HYPOSULPHITE OF CINCHONIDINE, obtained by precipitating the neutral sulphate with hyposulphite of sodium, crystallises on cooling, in long asbestos-like needles, sparingly soluble in water, easily in alcohol.

NITRATE OF CINCHONIDINE is obtained in mammellated crusts, having the appearance of enamel, and very soluble in water.

SULPHATES OF CINCHONIDINE.—The *neutral salt*, $2C^{20}H^{24}N^{2}O.H^{2}SO^{4}$ (at 100° C.), crystallises in long silky needles grouped in stars, neutral to test-paper. One pt. of the salt dissolves in 130 pts. water at 17° C., and in 16 pts. at 100°; it is very soluble in alcohol, nearly insoluble in ether (Leers); it dissolves at mean temperatures in 30—32 pts. absolute alcohol, and in 7 pts. alcohol of 90 per cent. (Bussy and Guibourt.)

Analysis (mean).	*Calculation.*	
Leers.	Leers.	Gerhardt.
At 100° C.	$2C^{18}H^{22}N^{2}O.H^{2}SO^{4}$	$2C^{20}H^{24}N^{2}O.H^{2}SO^{4}$
64·75	65·25	67·20
7·05	6·95	6·72
12·01	12·08	11·20

The *acid sulphate* is obtained by evaporation in vacuo, as a crystalline mass composed of shining asbestos-like needles.

Sulphate of Iodocinchonidine.—Cinchonidine forms with iodine and sulphuric acid, a crystalline salt, which acts upon light in the same manner as the corresponding salts of quinine and cinchonine, also two other salts, one yellow and the other olive-green, which do not exhibit these peculiar optical properties. (W. B. Herapath, Chem. Soc. Qu. J. xi. 130.)

Acetate of Cinchonidine crystallises in long silky needles, which are very sparingly soluble in cold water, and give off part of their acid on drying. The *butyrate* and *valerate* form mammellated crusts, having the odour of the respective acids.

The *citrate* forms small needles, having but little lustre. The *hippurate* crystallises in silky needles, having the aspect of fern-leaves, very soluble in water and alcohol. The *oxalate* separates on cooling in long silky needles, from a mixture of the hot alcoholic solutions of oxalic acid and cinchonidine. The mother-liquor deposits by spontaneous evaporation, dull white, mammellated crusts. The *quinate* crystallises in small needles, very soluble in water and in alcohol. The *neutral tartrate* forms beautiful needles, having a vitreous lustre. The *acid tartrate* forms small nacreous needles, very sparingly soluble in water.

METHYL-CINCHONIDINE, $C^{18}H^{21}(CH^3)N^2O$, or $C^{20}H^{23}(CH^3)N^2O$? (Stahlschmidt, Ann. Ch. Pharm. xc. 218.) The *hydriodate* of this base is obtained by the action of iodide of methyl on cinchonidine. It crystallises in colourless shining needles, containing:

	By Analysis.	*By Calculation.*	
	At 100° C.	$C^{18}H^{21}(CH^3)N^2O.HI$	$C^{20}H^{23}(CH^3)N^2O.HI$
Carbon . .	53·87	53·76	56·1
Hydrogen .	5·92	5·89	6·0
Iodine . .	29·84	29·87	28·0

Oxide of silver converts it into a basic compound resembling methyl-cinchonine.

CINCHONINE. $C^{20}H^{24}N^2O$, or $C^{40}H^{24}N^2O^2$. (Fourcroy, Ann. Chim. viii. 113; ix. 7.—Vauquelin, *ibid.* lix. 30, 148.—Gomez, Edinb. Med. and Surg. Journal, 1811, Oct. p. 420.—Pfaff, Schw. J. x. 365.—Pelletier and Caventou, Ann. Ch. Phys. xv. 291, 337.—Pelletier and Dumas, *ibid.* xxiv. 169.—Liebig, Ann. Ch. Pharm. xxvi. 49.—Regnault, Ann. Ch. Phys. lxviii. 113.—Gerhardt, Rev. scient. x. 886; *Traité*, iv. 105.—Laurent, Ann. Ch. Phys. [3] xix. 363.—Strecker, Compt. rend. xxxix. 58.)

This alkaloïd exists, together with quinine, in most of the true cinchona-barks, most abundantly in *Cinchona Huanoco*, *C. Huamalies*, *C. rubiginosa*, and *C. flava fibrosa*. (See table, p. 968.)

Preparation.—All methods of extracting the alkaloïds from cinchona-barks consist in treating the bark with a dilute acid, and precipitating the alkaloïds from the acid extract, with lime or carbonate of sodium, The general mode of proceeding is as follows:

The bark, reduced to powder, is boiled for an hour or less with 8 or 10 times its weight of water, acidulated with 10 per cent. of strong sulphuric acid, or better, with 25 per cent. of hydrochloric acid; the decoction is strained through a cloth; and the residue is boiled a second and sometimes a third time, with more and more dilute acid till the marc is completely exhausted. The extracts, after cooling, are mixed with a slight excess of milk of lime, added by small portions, to precipitate the alkaloïds together with the colouring matter. The precipitate is left to drain, and submitted to a gradually increasing pressure, the liquids which run off from the cloths and from the press being collected in a single vessel; they yield after a while a fresh deposit. The pressed cake is now dried, and macerated with alcohol in a closed vessel heated over a water-bath. The strength of the alcohol used depends upon the quality of the bark under treatment. For Calisaya bark, which is very rich in quinine, alcohol of 75 to 80 per cent. is sufficiently strong; but barks which contain a smaller proportion of quinine, require alcohol of 85 to 90 per cent., because cinchonine is much less soluble in weak alcohol than quinine.

If the bark is rich in cinchonine, and the quantity of alcohol used is not too large, the cinchonine is deposited in the crystalline state as the alcoholic extracts cool, and an additional quantity may be obtained by decanting the supernatant liquid, and distilling off half or two-thirds of the alcohol. The quinine remains in the mother-liquor and may be separated in the form of sulphate. (See QUININE.)

If on the other hand the bark contains more quinine than cinchonine, it is best to treat the alcoholic extract with dilute sulphuric acid, and remove the alcohol by distillation. The greater part of the sulphate of quinine then separates in a crystalline mass, the rest, together with the sulphate of cinchonine, remaining in the mother-liquor. By precipitating the two alkaloïds with carbonate of sodium, redissolving in sulphuric acid, and recrystallising, a further separation may be effected; or they may be precipitated by a caustic alkali, and separated by ether, which dissolves the quinine much more readily than the cinchonine (p. 966).

Carbonate of sodium is a better precipitant for the alkaloïds than lime, because they are soluble to a slight extent in lime-water and chloride of calcium.

Oil of turpentine, fixed oils, and chloroform may be used instead of alcohol for dissolving the alkaloïds from the crude precipitate thrown down by lime or soda; and these solvents have the advantage of not taking up so much of the colouring matter as alcohol does (p. 966); but they are better adapted for the preparation of quinine than of cinchonine, which is but sparingly soluble in either of them. (See QUININE.)

Properties.—Cinchonine deposited by slow evaporation of its alcoholic solution, forms colourless, shining, quadrilateral prisms or needles, which are anhydrous. It has a peculiar bitter taste, which however is slow in developing itself, on account of the sparing solubility of the substance. It is insoluble in cold water, and requires for solution 2500 parts of boiling water. In alcohol it is much less soluble than quinine, the solubility increasing however with the strength of the alcohol and the temperature. According to Duflos, strong alcohol dissolves 3 per cent of its weight of cinchonine. It is insoluble in ether, slightly soluble in chloroform, volatile oils and fixed oils.

The solutions of cinchonine have an alkaline reaction, and deflect the plane of polarisation of a luminous ray strongly to the right. An alcoholic solution acidulated with sulphuric acid gives $[\alpha] = +190\cdot40°$; acids produce a temporary decrease of the rotatory power. Cinchonine possesses febrifuge properties, but in a much lower degree than quinine.

The following are the mean results of the analyses of cinchonine by various chemists.

	Calculation.		Liebig.	Regnault.	Gerhardt.	Hlasiwetz.	Laurent.
C^{20} . .	240	77·93	76·36	76·78	77·63	77·97	77·29
H^{24} . .	24	7·79	7·37	7·69	7·98	7·75	7·68
N^2 . .	28	9·09	8·87	9·45	—	—	—
O . .	16	5·19	7·40	6·08	—	—	—
$C^{20}H^{24}N^2O$	308	100·00	100·00	100·00			

Laurent assigned to cinchonine the formula $C^{19}H^{22}N^2O$. According to Schützenberger (Jahresber f. Chem. 1858, p. 372), the name cinchonine is applied to bases of different constitution; one sample which he analysed yielded numbers agreeing with the formula $C^{18}H^{22}N^2O^2$.

Cinchonine melts at 165° C. forming a colourless liquid, which becomes crystalline on cooling; at a higher temperature, it partly sublimes, exhaling an aromatic odour. According to Hlasiwetz, cinchonine may be sublimed in hydrogen or ammonia gas in the form of shining prisms more than an inch long. Heated with *sulphuric acid and peroxide of lead*, it yields a red substance, cinchonetine, which has not been examined (Marchand, J. Chim. méd. x. 362). Other oxidising agents, *e. g.* nitric acid, permanganate of potassium, and a mixture of sulphuric acid and peroxide of manganese, do not exert much action upon it; neither is it decomposed in a definite manner by emulsin (Hlasiwetz). With *nitrous acid*, it forms a base containing 1 at. oxygen more than cinchonine, and isomeric with quinine, but approaching more nearly to cinchonine in its properties (Schützenberger, Jahresber. f. Chem. 1858, p. 371). It dissolves in *fuming sulphuric acid*, yielding sulpho-cinchonic acid, which forms a soluble barium-salt, $C^{20}H^{22}BaN^2O.SO^4$ (Schützenberger.) With *chlorine* and *bromine*, it forms several substitution-bases, as well as a resinous substance. With *chlorine* and *ammonia*, it does not exhibit the green colouring which is characteristic of quinine. With *iodine* and *iodated potassic iodide* it behaves like quinine. Distilled with *hydrate of potassium*, it yields chinoline, together with several other volatile bases (p. 869).

Beta-cinchonine.—Schwabe (J. Pharm. [3] xxxviii. 389), has obtained from commercial quinoïdine (a product of the alteration by heat of quinine, cinchonine, &c. found in the mother-liquors of the preparation of sulphate of quinine), an alkaloïd isomeric with cinchonine, but differing from it in many properties. This β-cinchonine is contained in the portion of quinoïdine which is sparingly soluble in alcohol; and the sulphate is obtained therefrom by dissolving the substance in dilute acid, precipitating with ammonia, treating the washed precipitate with cold alcohol of specific gravity 0·845, again dissolving it in dilute sulphuric acid, and crystallising. The base separated from the sulphate crystallises from boiling alcohol by spontaneous evaporation in rhombic combinations, $\infty P . \infty \breve{P} \infty . oP$ ($\infty P : \infty P = 119°$). The crystallised as well as the precipitated base is anhydrous, and melts at 150° C. β-cinchonine is more soluble in water, alcohol, ether, and chloroform than ordinary α-cinchonine. The following table gives the quantities of these several solvents required to dissolve 1 pt. of α and β cinchonine, as determined by Schwabe.

	α-Cinchonine.	*β-Cinchonine.*
Water, cold	insoluble	insoluble
Water, hot	2500	scarcely soluble
Alcohol, cold	—	173
Alcohol, hot	30	43
Ether	insoluble	378
Chloroform	40	265

alcoholic solution of β-cinchonine is dextro-rotatory.
chonine is precipitated white from the solutions of its salts by caustic or car-
d alkalis, the precipitate being somewhat soluble in excess of the reagent, and
earing when shaken up with ether. A solution of the base containing tartaric
not precipitated by acid carbonate of sodium. A neutral solution of the sul-
mixed with chlorine-water and then carefully with ammonia, exhibits a yellow
With ferrocyanide of potassium and chlorine, a red colouring is produced,
g green on addition of ammonia. Quinine-solutions thus treated, exhibit a dark
our; ordinary cinchonine and quinidine, wine-yellow.

ts of Cinchonine.—Cinchonine dissolves readily in acids. The salts are
and are very much like the corresponding salts of quinine, but for the most part
soluble in water and in alcohol. Ordinary cinchonine forms both acid and
l salts; β-cinchonine apparently only neutral salts.

TATE OF CINCHONINE.—A solution of cinchonine in acetic acid always exhibits
l reaction, however great may be the excess of cinchonine contained in it; but
entrated by heat, it deposits on cooling, small sparingly soluble crystals, which
t no acid reaction after washing. If the liquid be slowly evaporated to dryness,
my mass is obtained, which is decomposed by water into an acid salt which
es and a neutral salt which remains at the bottom. (Pelletier and Ca-
u.)

tate of β-Cinchonine forms right-angled four-sided prisms, like those of the
te and hydrochlorate. (Schwabe.)

ENATE of CINCHONINE.—Very soluble; difficult to crystallise.

BONATE OF CINCHONINE.—Cinchonine dissolves in aqueous carbonic acid more
than in pure water; but the solution does not yield a crystallised carbonate.

ORATE of CINCHONINE, $C^{20}H^{24}N^2O.HClO^4$.—White bulky crystalline tufts; melts
ntle heat, and decomposes with explosion at a higher temperature. (Serullas.)

OMATE OF CINCHONINE.—Obtained as a yellow amorphous precipitate, adhering
glass, but becoming crystalline after a while when a solution of sulphate of
nine is mixed with acid chromate of potassium. It is decomposed by water and
. (Elderhorst.)

NURATE OF CINCHONINE.—A solution of cinchonine in a boiling saturated so-
of cyanuric acid deposits rhomboïdal prisms, sparingly soluble in water, inso
n alcohol and ether. The salt gives off 17·79 per cent. water at 100° C; and
poses at 200°, exhaling an odour of bitter almonds. (Elderhorst.)

ICYANATE OF CINCHONINE, $2(C^{20}H^{24}N^2O.3HCy)Fe^2Cy^6 + 4aq.$—Orange-yellow
ate, obtained by mixing the aqueous solutions of hydrochlorate of cinchonine
icyanide of potassium. After drying in the air, it undergoes no alteration at
(Dollfus, Ann. Ch. Pharm. lxv. 224.)

OCYANATE OF CINCHONINE, $C^{20}H^{24}N^2O.4HCy.FeCy^2 + 2aq.$—Lemon-yellow pre-
produced on mixing the alcoholic solutions of cinchonine and ferrocyanic acid.
ry sparingly soluble in alchol, and when heated, either alone, or with water, is
osed, yielding hydrocyanic acid and a blue residue (Dollfus). *Ferrocy-
of β-cinchonine* is sparingly soluble and crystallisable. (Schwabe.)

IATE OF CINCHONINE.—Very soluble; crystallises from a syrupy solution in
eedles.

OTANNATE OF CINCHONINE.—Yellowish-white powder, very little soluble in cold,
luble in boiling water, whence it separates in transparent grains on cooling.

URATE OF CINCHONINE.—Uncrystallisable.

ROCHLORATE OF CINCHONINE.—The *neutral salt*, $C^{20}H^{24}N^2O.HCl$, obtained by
saturating cinchonine with weak hydrochloric acid; crystallises in transparent
rhomboïdal prisms; melts at 100° C.; dissolves easily in water and in alcohol,
insoluble in ether. The aqueous solution possesses dextro-rotatory power;
139·50° (Bouchardat). When subjected to electrolysis, it yields chloro-
ine, together with chlorine, oxygen, and hydrogen. (Babo.)

rochlorate of β-cinchonine, $C^{20}H^{24}N^2O.HCl + 2aq.$, crystallises apparently
bic combinations, $\infty P \,.\, \infty\breve{P}\infty \,.\, oP$, in which $\infty P : \infty P = 126\frac{1}{2}°$. It dissolves
s. of cold, 3·2 pts. of hot water; in 1 pt. of cold, ½ pt. of boiling alcohol, and
ts. of ether.

hydrochlorate of cinchonine, $C^{20}H^{24}N^2O.2HCl$, is produced by exposing
ine to hydrochloric acid gas, and is obtained crystallised by pouring a slight
f the acid on cinchonine, and dissolving the product in a mixture of water and
The solution left to evaporate very slowly in an unclosed bottle, deposits
ell-defined rhombic tabular crystals, having the acute angles truncated,
$\infty P = 101°$; $\breve{P}\infty : oP = 137$ to 138°. It is very soluble in water, rather
lcohol: reddens litmus. The solution is dextro-rotatory.

Chlorine passed into a solution of this salt, forms a deposit of acid hydrochlorate of dichlorocinchonine.

Chloromercurate, $C^{20}H^{24}N^2O.2HCl.HgCl^2$.—On mixing a solution of cinchonine in strong alcohol containing hydrochloric acid with a solution of mercuric chloride also in strong alcohol, the mixture solidifies after a while to a mass of small needles, nearly insoluble in cold water, ordinary alcohol, and ether, moderately soluble in boiling water, and in warm alcohol, easily soluble in strong hydrochloric acid. The salt may be dried at 100° C. without alteration.

Chloroplatinate, $C^{20}H^{24}N^2O.2HCl.PtCl^4$.—Light yellow precipitate, obtained by adding tetrachloride of platinum to a solution of acid hydrochlorate of cinchonine. With an alcoholic solution of cinchonine containing hydrochloric acid, the precipitate is crystalline and nearly white, and dissolves after prolonged boiling with water, the solution as it boils, depositing, first a whitish pulverulent precipitate, afterwards beautiful crystals of a deep orange colour. The salt contains, according to Hlasiwetz, 33·1 per cent. C, 3·6 H, and 27·36 Pt, the formula requiring 33·0 C, 3·3 H, and 27·36 Pt.

Chloroplatinate of β-cinchonine, $2(C^{20}H^{24}N^2O.HCl).PtCl^4$, crystallises on mixing the alcoholic solutions of its component salts, in rhombic combinations, $\infty P . \infty \breve{P} \infty . oP$, in which $\infty P : \infty P = 119$ (approximately). (Schwabe.)

Hydrocyanate of β-cinchonine, obtained by precipitation with cyanide of potassium, is amorphous, anhydrous, insoluble in water and alcohol. (Schwabe.)

Hydrofluate of Cinchonine, $C^{20}H^{24}N^2O.2HF$.—A solution of recently precipitated cinchonine in dilute hydrofluoric acid, deposits colourless prisms when concentrated. The salt crystallises easily from dilute alcohol in rhomboïdal prisms terminated by octahedral faces. After drying at mean temperature, it gives off 2·8 per cent. water at 160° C.; at a high temperature, it acquires a fine purple tint, yields a red sublimate, gives off hydrofluoric acid, and becomes carbonised.

Hydriodate of Cinchonine, $C^{20}H^{24}N^2O.HI + aq.$ (Regnault.)—Much less soluble than the hydrochlorate. Crystallises easily in nacreous needles. Its solution is precipitated by mercuric chloride and cyanide. *Hydriodate of β-cinchonine* is easily soluble in water and in alcohol. (Schwabe.)

Hyposulphate of Cinchonine.—Crystallisable; resembles the quinine-salt (*q.v.*)

Hyposulphite of Cinchonine.—Obtained by precipitation in small needles; very sparingly soluble in cold water. (Winckler.)

Iodate of Cinchonine, $C^{20}H^{24}N^2O.HIO^3$ (at 105° C.).—Long silky fibres, very soluble in water and alcohol. Explodes with violence at 120° C.

Nitrate of Cinchonine, $C^{20}H^{24}N^2O.HNO^3 + aq.$ (Regnault.)—Obtained by dissolving cinchonine in dilute nitric acid. If the solution is rather concentrated, part of the nitrate separates in oily globules, which, if covered with water, are converted in a few days into a group of oblique rectangular prisms, very soluble in water. The solution is dextro-rotatory, $[\alpha] = +172{\cdot}48°$ (Bouchardat). When decomposed by the electro-current (from six Bunsen's cells), it gives off oxygen at the positive pole, mixed after a while with carbonic acid and oxides of nitrogen, and at the negative pole, a mixture of hydrogen and nitrogen containing a little ammonia; in the liquid into which the negative pole dipped, a resinous substance was deposited, and the solution decanted therefrom and distilled with potash, yielded ammonia and oily drops of chinoline. (Babo, J. pr. Chem. lxxii. 73.)

Nitrate of β-cinchonine crystallises slowly, by spontaneous evaporation, in monoclinic or triclinic crystals, which are moderately soluble in water and alcohol, and do not effloresce. (Schwabe.)

Oxalates of Cinchonine.—The *neutral oxalate* is a white precipitate, insoluble in cold, slightly soluble in boiling water, very soluble in alcohol, especially if hot, and in oxalate of ammonium. The *acid oxalate* is much more soluble than the neutral salt. *Oxalate of β-cinchonine* is crystallisable. (Schwabe.)

Oxalurate of Cinchonine.—Obtained by saturating a boiling solution of parabanic acid with excess of cinchonine. The solution dries up to a yellowish transparent mass, which whitens a little as it assumes the crystalline form. When boiled with hydrochloric acid, it dissolves, producing oxalic acid. (Elderhorst.)

Perchlorate of Cinchonine, $C^{20}H^{24}N^2O.HClO^4 + aq.$—Obtained by decomposing sulphate of cinchonine with perchlorate of barium. Large rhomboïdal prisms, having a strong lustre, and exhibiting a fine blue and yellow dichroïsm, even in very dilute solutions. Very soluble in water and alcohol. Melts and gives off its water at 160° C. and decomposes with explosion at a higher temperature. The salt dried at 30° C. gives off 3·57 per cent. water at 160° (Boedeker, jun. Ann. Ch. Pharm. lxxi. 59). According to Dauber (*ibid.* 66), the crystals belong to the diclinic system of Naumann (see Crystallography), being rhomboïdal prisms of 125° 47′ and 54° 13′ with perpendicular truncation of the acute edges.

ODATE OF CINCHONINE.—Very unstable prisms, obtained like the perchlorate
iug to Langlois, periodic acid oxidises cinchonine more rapidly than quinine.

SPHATE OF CINCHONINE.—Very soluble. A solution of cinchonine in phosphoric
ields by evaporation, sometimes rudimentary crystals, but more generally amor-
transparent plates, which gradually become crystalline by contact with water.
sphate of β-cinchonine forms crystals nearly a line in length, and appa-
oblique-angled. (Schwabe.)

ATE OF CINCHONINE.—Yellow pulverulent precipitate, nearly insoluble in water,
luble in alcohol.

ATE OF CINCHONINE.—A strong aqueous solution of cinchonine in quinic acid
s, when left at rest, sometimes silky needles, sometimes a mammellated mass of
ranules. The salt dissolves in half its weight of water at 25° C.: it contains
of crystallisation. From a solution in warm alcohol, it crystallises on cooling in
ess, shining, short, compressed prisms, apparently unalterable either by ex-
to the air or by a moderate heat, but becoming completely opaque in course of
Water dissolves them very readily, but with partial decomposition. Their
s solution turns reddened litmus blue, but the alcoholic liquid from which they
eposited, turns blue litmus red.

PHATES OF CINCHONINE.—The *neutral sulphate*, $2C^{20}H^{24}N^2O.H^2SO^4 + 2$ aq., is
d by exactly saturating cinchonine with dilute sulphuric acid. It forms rhombic
of 83° and 97°, generally very short, and having their ends truncated or
d: cleavable parallel to the prismatic faces; sometimes hemitropic. They are
ransparent, and have a vitreous lustre; permanent in the air; melt a little
00° C. and give off their 2 at. water between 100° and 120°. They dissolve at
emperatures in 54 pts. water, 6½ pts. alcohol of specific gravity 0·85, and 11½ pts.
e alcohol; insoluble in ether (Baup). It is but slightly decomposed by the
current.

nate of cinchonine becomes phosphorescent at 100° C. like sulphate of quinine.
ner temperatures, it melts and then decomposes, yielding a resinous matter of a
l colour. But if the salt be previously mixed with a little water and sulphuric
remains liquid at a low temperature, even after all the water has been driven
d if kept in this state for three or four hours at 120° to 130° C. it is completely
rmed into sulphate of cinchonicine, only a very small quantity of colouring
being then produced. (Pasteur, p. 969.)

phate of β-cinchonine, $2C^{20}H^{24}N^2O.H^2SO^4 + 2$ aq.—Crystallises in rhombic
ations $\infty P . \infty \breve{P} \infty . o P$, in which $\infty P : \infty P = 136°$. It dissolves in 75 pts. of
d 14 pts. of hot water; in 13·6 pts. of cold, and 1·5 pts. hot alcohol of 80 per
nd is insoluble in ether. The dilute aqueous solution is strongly iridiscent.
abe.)

l Sulphate of Cinchonine, $C^{20}H^{24}N^2O.H^2SO^4 + 3$ aq.—By adding sulphuric
the neutral sulphate, and evaporating till a slight pellicle is formed, the acid
obtained in rhombic octahedrons, often having some of their edges or summits
d, and cleaving very easily, at right angles to the axis, in well-defined shining
It is permanent in the air at ordinary temperatures, but effloresces in very
or if slightly warmed. When heated, it gives off 11·73 per cent. water = 3 at.
C., 100 pts. of the salt [? anhydrous or hydrated], dissolve in 46 pts. water, in
of alcohol, of specific gravity 0·85, and in 100 pts. of absolute alcohol: it is
le in ether. (Baup, Ann. Ch. Phys. [3] xxvii. 323.)

HOCYANATE OF CINCHONINE, $C^{20}H^{24}N^2O.HCyS$, crystallises in brilliant anhy-
eedles (Dollfus). *Sulphocyanate of β-cinchonine* is also crystallisable.
abe.)

RATES OF CINCHONINE. (Pasteur, Ann. Ch. Phys. [3] xxxviii. 456, 469.—
, J. pr. Chem. liii. 331.)—These salts, neutral and acid, dextro- or lævo-rota-
e prepared by dissolving cinchonine in the proper proportions in the two modi-
s of tartaric acid.

eutral, $2C^{20}H^{24}N^2O.C^4H^6O^6 + 2$ aq.—Large needles grouped in bundles, spar-
luble in water, and giving off their crystallisation-water, 4·6 per cent., between
d 120° C. (Arppe.)

cid Tartrates.—The *dextro-rotatory salt*, $C^{20}H^{24}N^2O.C^4H^6O^6 + 4$ aq., forms
s shining crystals grouped in radiate stars. They belong to the trimetric
and are often hemihedral. Observed combination, $\infty P . \breve{P} \infty . P$. Inclination of
$P : \infty P = 133° 20'$ (nearly); $\breve{P} \infty : \breve{P} \infty = 127° 40'$; $\frac{P}{2} : \breve{P} \infty = 151° 13'$. The
P are longitudinally striated. It gives off its water (13·75 – 14·0 per cent.:
ion, 13·58 per cent.) at 100° C., and at 120°, assumes a red colour and begins

to melt. It dissolves but sparingly in cold, much more easily in hot water, still more in alcohol; the solution is neutral to test-paper.

A solution containing twice the quantity of tartaric acid required to form this salt, deposits at first, another acid tartrate in transparent well-defined crystals.

Lævo-rotatory acid tartrate, $C^{20}H^{24}N^2O.C^4H^6O^6 + aq.$—This salt gives off its water = 4·58 per cent. (calc. 3·78), at 100° C. It is very sparingly soluble in alcohol and in water; the alcoholic solution is neutral, the aqueous solution acid to test-paper.

If a great excess of acid is used in the preparation, another acid tartrate is obtained crystallised in brilliant tufts, composed of very slender needles, and very different in appearance from the second dextro-rotatory acid tartrate above-mentioned. (**Pasteur.**)

URATE OF CINCHONINE, $C^{20}H^{24}N^2O.C^5H^4N^4O^3 + 4\ aq.$—Obtained by boiling uric acid with cinchonine recently precipitated and diffused through a large quantity of water. The liquid filtered at the boiling heat, deposits long prisms sparingly soluble in water, boiling alcohol, and ether. On heating the salt to 100° C. or leaving it to evaporate over oil of vitriol, it becomes opaque, and finally assumes a sulphur-yellow colour, giving off 12·49 per cent. (calc. 4 at. = 13·73 per cent.). During the desiccation, it is in a state of constant agitation, and is finally converted into a crystalline powder, probably differing in form from the hydrated crystals. (**Elderhorst**, *loc. cit.*)

Brominated, Chlorinated, and Iodated Derivatives of Cinchonine.

BROMOCINCHONINE, $C^{20}H^{23}BrN^2O$. (**Laurent**, Ann. Ch. Phys. [3] xxiv. 302.)—When bromine is poured upon moist acid hydrochlorate of cinchonine, a product is obtained, which, when freed from excess of bromine by washing with a little alcohol, is a mixture of acid hydrobromate or hydrochlorate of bromocinchonine and sesquibromocinchonine. On treating it with boiling alcohol, the former of these salts dissolves, while the latter is nearly insoluble; and on adding ammonia to the decanted solution, boiling to expel part of the alcohol, and leaving it to cool, bromocinchonine is deposited in laminæ, which may be purified by recrystallisation.

The *acid hydrochlorate*, $C^{20}H^{23}BrN^2O.2HCl$, crystallises in the same form as the corresponding salt of cinchonine. The *chloroplatinate*, $C^{20}H^{23}BrN^2O.2HCl.PtCl^4$, is a pale yellow powder, containing at 50° C. 24·2 per cent. platinum (calc. 24·75).

SESQUIBROMOCINCHONINE, $C^{20}H^{22\cdot5}Br^{1\cdot5}N^2O$. (**Laurent**, *loc. cit.*)—When the pulverulent residue, insoluble in boiling alcohol, obtained in the preparation just described, is boiled with water, and ammonia added, a white bulky precipitate of sesquibromocinchonine is formed, which, after washing and drying, dissolves in boiling alcohol, and crystallises therefrom in slender needles. It is slightly bitter; its alcoholic solution turns reddened litmus blue. It melts when heated, afterwards blackens with intumescence. It gives by analysis 55·45 per cent. C, 5·18 H, and 28·3 Br, the formula requiring 56·27 C, 5·27 H, and 28·13 Br.

The *acid hydrochlorate*, $C^{20}H^{22\cdot5}Br^{1\cdot5}N^2O.2HCl$, forms rhombic tables, in which $\infty P : \infty P = 107°$ to 108°.

The *hydrobromochlorate*, $C^{20}H^{22\cdot5}Br^{1\cdot5}N^2O.HCl.HBr$, is obtained by pouring bromine on hydrochlorate of cinchonine; boiling with alcohol as above, to remove hydrochlorate of bromocinchonine; again pouring alcohol on the residual salt; boiling; adding ammonia, which dissolves it immediately; then adding excess of hydrochloric acid to the solution, and leaving it to cool. The salt is then deposited in small rhombic tables, in which $\infty P : \infty P = 107°$ to 108°.

The *chloroplatinate*, $C^{20}H^{22\cdot5}Br^{1\cdot5}N^2O.2HCl.PtCl^4$, is a very pale-yellow precipitate, containing at 100° C. 23·0 per cent. platinum; by calculation, 23·5.

DIBROMOCINCHONINE, $C^{20}H^{22}Br^2N^2O$. (**Laurent**, Compt. chim. 1849, p. 311.)—Bromine in excess is poured on acid hydrochlorate of cinchonine, to which a little water has been added; the product is heated when the action is over, to complete the bromination of the cinchonine, and expel excess of bromine; water is then poured upon it; the liquid is boiled and filtered; alcohol is added to the aqueous filtrate, heat again applied, and the solution is neutralised with ammonia. On cooling, it deposits dibromocinchonine in colourless laminæ, with nacreous reflexion.

Dibromocinchonine is insoluble in water, sparingly soluble in boiling alcohol. At about 200° C. it swells, blackens, and yields a substance which dissolves easily in potash, and is separated therefrom by acids in brown flakes. Dibromocinchonine gives by analysis 51·20 per cent. C, 4·4 H, and 34·00 Br, the formula requiring 51·28 C, 4·70 H, and 34·19 Br. A solution which had been left for some days in an open vessel, deposited rectangular octahedrons, containing 4·2 per cent. = 1 at. water of crystallisation.

The *acid hydrochlorate*, $C^{20}H^{22}Br^2N^2O.2HCl$, obtained by treating the base with hydrochloric acid, is sparingly soluble in water, and separates from a boiling solution on cooling, in rhombic tablets, having their four acute angles truncated: $\infty P : \infty P =$

105° : $\breve{P}\infty$: oP = 137. Its solution deflects the plane of polarisation to the

HLOROCINCHONINE, $C^{20}H^{22}Cl^2N^2O$. (Laurent, Ann. Ch. Phys. [3] xxiv. 302.)
acid hydrochlorate of this base is formed by passing chlorine into a hot concen-
solution of acid hydrochlorate of cinchonine; and on adding ammonia to a
of this salt in boiling water, the base is precipitated as a light flocculent mass,
crystallises from boiling alcohol in microscopic needles, yielding by analysis
r cent. chlorine (calc. 18·83).

acid hydrochlorate, $C^{20}H^{22}Cl^2N^2O.2HCl$, is sparingly soluble in water, and
s 50 pts. of alcohol to dissolve it: the solution is dextro-rotatory. The salt
lises in rhombic tables isomorphous with the crystals of acid hydrochlorate oı
ine, $\infty P : \infty P = 106°$; $P\infty$: oP = 136° 30′ to 137° 30′.

chloroplatinate, $C^{20}H^{22}Cl^2N^2O.2HCl.PtCl^4$, is a pale yellow powder, yield-
100°, 25·00 per cent. platinum (calc. 25·06).

acid hydrobromate, $C^{20}H^{22}Cl^2N^2O.2HBr$, obtained by treating the base with
romic acid, is sparingly soluble, and crystallises in brilliant laminæ, having sensibly
e angles as those of the acid hydrochlorate, but presenting a different appearance,
ch as the modifying faces are considerably developed, so that the rhombic tablet
formed into a six-sided prism; $\infty P : \infty \breve{P} = 104°$; $\breve{P}\infty$: oP = 137°. The salt
same composition as the acid hydrochlorate of dibromocinchonine, but differs
in giving with nitrate of silver a precipitate of bromide of silver, whereas the
ields a precipitate of chloride.

nitrate is sparingly soluble in water, and crystallises in small elongated tetra-
s, formed of four equal scalene triangles, and having their opposite edges trun-

OCINCHONINE, $2C^{20}H^{24}N^2O.I^2$ (?) (Pelletier, Ann. Ch. Phys. [2] lxiii. 181.)—
cinchonine is triturated with about half its weight of iodine, and the product is
with alcohol of 36 per cent., the whole dissolves, and on leaving the solution to
ate, it first deposits the so-called iodocinchonine in saffron-coloured plates, after-
crystalline nodules of hydriodate of cinchonine. On treating the whole with
water, the hydriodate dissolves, and the iodocinchonine separates in the melted

cinchonine has a deep saffron-yellow colour when seen in mass; its powder is
It has a slightly bitter taste. When heated, it softens at 25° C. but does
er into complete fusion till heated to 80°. It is insoluble in cold water, very
in boiling water, soluble in alcohol and ether. It gave by analysis 28·83 per
dine (calc. 29·03).

cinchonine may be decomposed by the successive action of acid and alkaline
s. It is likewise decomposed by nitrate of silver. (Pelletier.)

e preceding formula be correct, the compound is not iodocinchonine, but iodide
onine.

phate of Iodocinchonine. (W. B. Herapath, Chem. Soc. Qu. J. xi. 151.)—
nine treated with iodine and strong sulphuric acid, yields a crystalline salt, which
les the corresponding quinine-compound in its action on light. It crystallises in
edles, which appear deep purple-red by transmitted, and dark purple-blue by re-
light; their laminæ appear lemon-yellow by transmitted light, and if two such
ates be superposed in such a manner that their longest dimensions may cross
ther at right angles, the system is perfectly impervious to light, the two plates
in fact like two tourmalines with their axes crossed. (For further details re-
o these properties, see SULPHATE OF IODOQUININE, under QUININE). The salt
es easily in strong boiling alcohol, and crystallises therefrom; sparingly in
lcohol, and scarcely at all in water, ether, and chloroform. Herapath assigns
e formula $C^{20}H^{28}N^4O^2I^6.H^2SO^4 + 3aq.$, which is very improbable.

hate of Iodo-β-cinchonine is obtained in indistinct crystals on adding a warm
of 3 pts. iodine in 115 pts. alcohol to a solution of 10 pts. of sulphate of β-cin-
in 144 pts. acetic acid, and 12 pts. dilute sulphuric acid. (Schwabe.)

Derivatives of Cinchonine containing Organic Radicles.

ZOYL-CINCHONINE, $C^{27}H^{28}N^2O = C^{20}H^{23}(C^7H^5O)N^2O$. (Schützenberger,
h. Pharm. cviii. 351.)—Dry cinchonine dissolves with rise of temperature in
of benzoyl, and the mixture, if heated for a few seconds, solidifies to a crystalline
hydrochlorate of benzoyl-cinchonine. This salt dissolves readily in water, and
tion, quickly decanted from undissolved chloride of benzoyl, yields with ammonia
glutinous precipitate of benzoyl-cinchonine, which hardens in the cold. It is
and uncrystallisable, insoluble in water, but dissolves in all proportions in

alcohol and ether. Its salts are easily soluble in water. The *hydrochlorate* is $C^{27}H^{28}N^2O.HCl$; the *chloroplatinate* $C^{27}H^{28}N^2O^2.\ 2(HCl.PtCl^2)$.

METHYL-CINCHONINE, $C^{21}H^{26}N^2O = C^{20}H^{23}(CH^3)N^2O$. (Stahlschmidt, Ann. Ch. Pharm. xc. 218.)—The *hydriodate* of this base, $C^{21}H^{26}N^2O.HI$, is produced by the action of iodide of methyl on pulverised cinchonine. It dissolves easily in boiling water, and separates in fine needles on cooling. It is not attacked by iodide of methyl when heated therewith to 100° C. in a sealed tube: hence cinchonine appears to contain but 1 at. of hydrogen replaceable by an alcohol-radicle.

The iodide treated with oxide of silver, yields a solution of the base, which, when quickly evaporated over the water-bath, leaves a brown crystalline mass, from which, when dissolved in water, brown oily drops separate. The aqueous solution precipitates the salts of sesquioxides.

The salts of methyl-cinchonine are very soluble in water and in alcohol, and difficult to crystallise.

The *chloroplatinate*, $C^{21}H^{26}N^2O.2HCl.PtCl^4$, yields when dried at 100° C., 26·70—26·77 per cent. platinum, the formula requiring 26·93.

CINCHOVATINE. Syn. with ARICINE (p. 357).

CINNABAR. Protosulphide of mercury. (See MERCURY.)

CINNAMEIN. *Cinnamate of Benzyl.* $C^{16}H^{14}O^2 =$ $\left.\begin{matrix}C^9H^7O\\C^7H^7\end{matrix}\right\}O$. (Plantamour, Ann. Ch. Pharm. xxvii. 329; xxx. 241.—Frémy, Ann. Ch. Phys. lxx. 189.—H. Deville, Ann. Ch. Pharm. lxxiv. 230.—E. Kopp, Compt. chim. 1850, p. 410.—Scharling, Ann. Ch. Pharm. xcvii. 184.—Gm. xiii. 283.—Gerh. iii. 404.)—This compound was discovered by Plantamour (1838), who obtained it from balsam of Peru, in which, according to Simon, it exists ready formed; according to Frémy and Deville, it exists also in small quantity in Tolu balsam. According to Scharling, cinnamic acid dissolved in peruvin (a mixture of benzylic alcohol and toluene) forms a liquid, which, when saturated with hydrochloric acid, yields to boiling water a neutral oil resembling cinnamein.

Preparation.—Balsam of Peru is saponified by agitation with excess of caustic potash, and the solid soap dissolved in water: the solution on being warmed, separates after a few minutes into two layers, and the upper, which is oily, is to be repeatedly washed with water, till the oil exhibits a faint reddish-yellow colour. The residual water is evaporated over the water-bath; the oil dissolved in warm alcohol and evaporated; and this treatment repeated as long as resin separates out on evaporation. (Plantamour).—2. Balsam of Peru dissolved in alcohol of 36°, is treated with alcoholic potash, whereby a compound of resin with potash is precipitated; the solution is mixed with water; the cinnamein which separates out in the form of an oil is separated from the inferior solution of cinnamate of potassium, and dissolved in freshly-rectified rock-oil, whereby resin is removed; the rock-oil is then evaporated, and the residual oil placed in a vacuum. Cinnamein thus prepared, still retains styracin in solution, the quantity varying according to the nature of the balsam. To free it from this impurity, it is dissolved in weak alcohol, and cooled for several days below 0°, as long as a crystalline deposit of styracin continues to form (Frémy).—3. Balsam of Peru is repeatedly boiled with aqueous carbonate of sodium, and the cinnamate of sodium is removed by washing, the residue then separating into a resin, and a yellowish-brown liquid which must be heated to 170° C. on the oil-bath, and distilled in steam heated to 170°. Colourless, somewhat milky cinnamein then passes over, and is freed from adhering water by standing for some time in a warm place, over chloride of calcium. Sometimes, perhaps always, the cinnamein thus prepared contains in solution styracin, which, after long standing, partially crystallises out (Scharling). Calcined magnesia or oxide of lead also separates cinnamein from balsam of Peru, by combining with the cinnamic acid, and separating resin. (Simon.)

Properties.—Cinnamein is a feebly coloured or colourless, strongly refracting, neutral oil, which remains liquid when cooled to −12° or −15° C. for several days. It boils at 305°, and distils without decomposition (Plantamour); between 340° and 350°, with partial decomposition (Deville, Frémy). It has a feeble pleasant odour. Its taste is sharp and aromatic, recalling that of fat. It makes grease spots on paper. Specific gravity, 1·098 at 14°; 1·0925 at 25° (Scharling). It is nearly insoluble in water, but dissolves in alcohol and ether.

Cinnamein contains, according to Scharling's analysis, 79·18 to 79·24 per cent. C, 6·56 to 6·03 H, and 14·26 to 13·72 O, agreeing nearly with the preceding formula, which requires 80·62 C, 5·88 H, and 13·45 O.—When kept under water for some time, it yields a crystalline substance of the same composition, metacinnamein, which melts between 12 and 15° C. sometimes resolidifies after cooling and standing, but after solution in boiling alcohol cannot again be obtained in the crystalline form. (Scharling.)

mein slowly absorbs moist *oxygen* (Frémy). When exposed for years to *air*
ht, it acquires a rancid odour and acid reaction. Crystallised cinnamein preserved
ss vessel for a year melted to a viscous mass, and in another year solidified to a
rent amorphous mass (Scharling). Cinnamein is partially decomposed by dis-
, leaving a small quantity of tar, and yielding a distillate differing in compo-
rom the original substance.

resinised by strong *sulphuric acid* (Frémy). It slowly absorbs *chlorine*, more
when heated, becoming at the same time coloured and thickened, and when dis-
ultimately yields chloride of benzoyl together with an oil (Frémy). *Nitric*
ts briskly on cinnamein when heated, forming a yellow resin and a large
y of bitter almond oil *Peroxide af lead* acts in a similar manner (Frémy).
nein forms a crystalline compound with *ammonia* (Plantamour). Mixed with
e of carbon and powdered hydrate of potassium, it forms a saline mass con-
xanthate of potassium (Scharling). Rapidly heated with very concentrated
ley, or melted with hydrate of potash, it gives off hydrogen, and passes into
ate (and benzoate) of potassium (Frémy). Treated with very concentrated
ley in the cold, or with alcoholic potash, it is completely resolved, in 24 hours,
t disengagement of gas or absorption of oxygen, into benzylic alcohol and cin-
of potassium: $C^{16}H^{14}O^2 + KHO = C^7H^8O + C^9H^7KO^2$. By the continued
of the potash, the benzylic alcohol may be converted into benzylene. (C^7H^6.)
tamour, by treating cinnamein with strong alcoholic potash, obtained, together
nnamic acid, an acid which he designated as *carbobenzoic* or *myroxylic acid*;
ly impure benzoic acid resulting from the decomposition of cinnamic acid under
uence of potash (p. 984).

NNAMENE. C^8H^8. *Cinnamol. Styrol. Volatile Oil of Liquid Storax.* (Bo-
e, J. Pharm. xvii. 338.—D'Arcet, Ann. Ch. Phys. lxvi. 110.—Mulder, J. pr.
xv. 307.—E. Simon, Ann. Ch. Pharm. xxxi. 265.—C. Herzog, Pharm. Centr.
. 833.—Gerhardt and Cahours, Ann. Ch. Phys. [3] i. 96.—E. Kopp, Compt.
1846, p. 87; further. Compt. rend. liii. 634.—Blyth and Hofmann, Ann. Ch.
. liii. 293, 325.—Hempels, *ibid.* lix. 316.—Scharling, *ibid.* xcvii. 184.—
ward, Chem. Soc. Qu. J. xiii. 134; Gm. xiii. 1; Gerh. iii. 374.)—This compound
uced by the decomposition of cinnamic acid (p. 981), and is contained in liquid
(p. 982), whence it may be obtained by distillation with water. It was for-
supposed that cinnamene obtained from cinnamic acid was not identical, but
omeric, with styrol, the volatile oil of storax, because the latter is completely
ted by heat into a solid substance, *metastyrol*, of the same composition, whereas
innamene this change had been observed to take place but imperfectly; but E.
has lately shown that this transformation takes place quite as completely with
nene as with styrol, an observation which removes the only objection to the sup-
identity of the two substances.

paration.—a. From Cinnamic Acid and the Cinnamates. Cinnamic acid, when
distilled at its boiling point, is completely resolved into cinnamene and carbonic
ride:

$$C^9H^8O^2 = CO^2 + C^8H^8.$$

innamate of calcium is likewise resolved by dry distillation into cinnamene and
ate of calcium (D. Howard). Cinnamic acid distilled with excess of lime or
yields a mixture of cinnamene and benzene, which may be separated by rec-
on.

From Storax.—The liquid balsam is distilled in a copper still connected with a
tub, with water containing carbonate of sodium, to retain cinnamic acid; 3½ lbs.
bonate of sodium suffice for 10 lbs. of storax. The water which passes over is
and the cinnamene floats on the surface. The quantity obtained varies with the
the balsam. Blyth and Hofmann obtained in one operation about 360 grammes
from 20½ kil. of liquid storax, in another not more than 90 grms. from 13½ kil.
ly distillate is dried over chloride of calcium and rectified. This last operation
es particular precautions. The liquid begins to give off vapour between 100° and
., and at 145° it is in full ebullition, a limpid oil then passing over, and the
ometer remaining stationary for some time; suddenly, however, a considerable
kes place, and the thermometer must then be quickly withdrawn from the retort,
residue thickens, and on cooling solidifies to a transparent glass, consisting of
nnamene or metastyrol. The quantity of this solid residue varies, but it some-
amounts to half the oil subjected to distillation.

innamene may also be obtained from the resin of Peru balsam, by heating that
nce mixed with pumice to dull redness in a retort, and subjecting the oil which
over, together with benzoic acid and an aqueous liquid, to fractional distillation.
ortion which goes over under 175° C., and is lighter than water, is collected, re-
ly distilled with potash-solution, allowed to stand several days over pieces of solid

potash, and then distilled at a temperature not exceeding 150° C. The distillate is dried with chloride of calcium, treated with potassium, whereby hydrogen is evolved, and the fluid part is decanted from the resulting gelatinous precipitate and distilled. The boiling point then gradually rises to 100°—140° C., by which time all the cinnamene remains behind, amounting to ⅔ of the liquid employed. (Scharling, Ann. Ch. Pharm. xcvii. 184.)

Cinnamene is a very mobile colourless oil, having a strong persistent aromatic odour, reminding of benzene and naphthalene together. It does not solidify at −20° C. It is very volatile, the grease spots which it produces on paper disappearing in a few seconds. Specific gravity 0·924. Boiling point 145·75° C. (Blyth and Hofmann); 145° (E. Kopp). It is neutral, mixes in all proportions with alcohol and ether, volatile oils, and sulphide of carbon, and dissolves sulphur and phosphorus.

Cinnamene is not acted upon by *potash*. With *fuming sulphuric acid* it appears to form a conjugated acid. If added by drops to *fuming nitric acid*, it dissolves with evolution of red vapours; and water added to the solution throws down a yellow resin, which, by careful distillation, yields crystals of nitrocinnamene. If boiled with excess of nitric acid, it yields benzoic or nitrobenzoic acid, according to the strength of the nitric acid. Distilled with dilute *chromic acid*, it yields crystals of benzoic acid. With *chlorine* and *bromine*, it forms chloride and bromide of cinnamene.

METACINNAMENE. *Metastyrol. Draconyl.*—This is the solid substance into which cinnamene or styrol is converted by the action of heat. The conversion takes place readily in a sealed tube heated to 200° C. in an oil-bath. Metacinnamene is likewise obtained from dragon's blood. When the crude oil produced by the dry distillation of that substance is distilled till the temperature rises to 280° C. a liquid is obtained containing toluene (hydride of benzyl, p. 573), and cinnamene. On distilling this mixture at a temperature below the boiling point, till the greater part of the toluene has passed over, a viscous liquid remains, consisting of metacinnamene, held in solution by a small quantity of styrol. On pouring this liquid into alcohol, the cinnamene dissolves, while the metacinnamene is precipitated in the form of a soft colourless resin like turpentine, which may be washed with alcohol, and then dried in a stove at 150° C.

According to E. Kopp, the transformation of cinnamene into metacinnamene likewise takes place spontaneously at ordinary temperatures. This property, joined to the high refracting power of metacinnamene, suggests the possibility of using cinnamene for filling hollow glass lenses or prisms. According to Kovalevsky (Ann. Ch. Pharm. cxx. 66), metacinnamene exists also, together with cinnamene, in liquid storax.

Metacinnamene is a colourless, limpid, highly refractive substance, destitute of taste and odour. At mean temperatures it is hard, and may be cut with a knife; but it softens by heat, and may then be drawn out into long threads. It is insoluble in water and alcohol; ether dissolves it in small quantity, and at the boiling heat transforms it into a gelatinous mass, which, after drying at 100° C., forms a white spongy substance, having exactly the composition of styrol.

Metacinnamene liquefies when heated in a small retort, and yields by distillation pure cinnamene, which may be reconverted into metacinnamene by heating to 200° C. in a sealed tube.

Chlorine and *bromine* act very slowly on metacinnamene, but ultimately convert it into chloride and bromide of cinnamene respectively. Strong *sulphuric* acid carbonises it. By fusion with *hydrate of potassium* it is converted into styrol. *Nitric acid* of ordinary strength acts but slightly on metacinnamene, but fuming nitric acid dissolves it easily, with evolution of red vapours; and if the acid has been added in sufficient quantity, the solution yields with water a precipitate of nitrometacinnamene.

Compounds and Derivatives of Cinnamene.

BROMIDE OF CINNAMENE. $C^8H^8Br^2$.—Produced by the action of bromine on cinnamene. It is insoluble in water, but very soluble in alcohol and ether, whence it crystallises in needles. Solutions saturated at the boiling heat usually deposit it in the form of an oil, which remains liquid for a long time, and solidifies suddenly when agitated. It has a peculiar odour, which is not disagreeable, but excites tears. It melts at 67° C., and often remains liquid, even when cooled to 30° C., but the least agitation causes it to solidify in a crystalline mass. Its boiling point is above 200° C. It may be distilled almost wholly without alteration. Alcoholic potash converts it into bromide of potassium and a brominated organic compound.

Chloride of Cinnamene.—$C^8H^8Cl^2$. Oily liquid, produced by the action of chlorine on cinnamene. It is decomposed by distillation into hydrochloric acid and another oily compound.

Treated with alcoholic potash, it yields chlorocinnamene, C^8H^7Cl.

Trichloride of Dichlorocinnamene, $C^8H^6Cl^2.3Cl^2$, is obtained, according to Laurent, by the action of chlorine on cinnamene.

NITROCINNAMENE. *Nitrostyrol.* $C^9H^7(NO^2)$.—Produced by the action of fuming nitric acid on cinnamene (p. 980). It crystallises in large prisms; has an odour of cinnamon which excites tears; produces painful blisters on the skin.

Nitrometacinnamene. Nitrometastyrol. Nitrodraconyl.—This compound, isomeric with the last, is precipitated on adding water to the product of the action of fuming nitric acid on metacinnamene. It is a white amorphous powder, insoluble in water, acids, potash, ether, and alcohol. When slightly heated, it burns with explosion. When distilled with lime, it is decomposed, with separation of carbon and evolution of ammonia, together with a small quantity of a brown oil containing phenylamine. It does not appear to be attacked by strong nitric acid, even after several hours' boiling.

CINNAMIC ACID. $C^9H^8O^2 = \left.\begin{matrix}C^9H^7O\\H\end{matrix}\right\}O$. *Zimmtsäure. Cinnamylsäure.* (Dumas and Péligot [1834], Ann. Ch. Phys. lvii. 311.—E. Simon, Ann. Ch. Pharm. xxxi. 265.—Stenhouse, *ibid.* lv. 1; lvii. 79.—Herzog, Arch. Pharm. xvii. 72; xx. 159.—E. Kopp, Compt. chim. 1847, p. 198; 1849, p. 146; 1850, p. 140.—Cahours, Ann. Ch. Phys. [3] xxiii. 341.—Schabus, Wien Akad. Ber. 1850 [2] 206.—Chiozza, Ann. Ch. Phys. [3] xxxix. 439.—J. Löwe, J. pr. Chem. lxv. 188.—Piria, Ann. Ch. Pharm. c. 104.—Bertagnini, Cimento, iv. 46.—Gm. xiii. 268.—Gerh. iii. 388.)—This acid exists in the free state in several balsams, as in liquid storax, Tolu balsam, Peru balsam, and gum benzoin, and is often deposited in large prismatic crystals from old samples of oil of cinnamon; also from cinnamon-water.

Formation.—Cinnamic acid is produced: 1. By the action of oxidising agents on cinnamic aldehyde and on styrone.—2. By heating bitter-almond oil with chloride of acetyl in a sealed tube to 120°—130° C., but not higher, for 20—24 hours, hydrochloric acid being formed at the same time:

$$C^7H^6O + C^2H^3O.Cl = HCl + C^9H^8O^2.$$

The cinnamic acid may be extracted from the viscid residue by digestion with water containing ammonia.—3. By boiling cinnamein with potash, benzylic alcohol being formed at the same time (p. 979).—4. By fusing styracin with potash (Frémy) or boiling it with potash-ley. (Simon.)

Preparation.—*a.* From the deposit of cinnamate of lead mixed with cinnamic acid, found in the old leaden packages in which oil of cassia-cinnamon is imported. The deposit is dissolved in alcohol and filtered from the cinnamate of lead, and the alcohol is removed from the filtrate by distillation; the cinnamic acid then quickly crystallises out from the oil, and is purified by treatment with carbonate of sodium and precipitation. The residual cinnamate of lead is boiled with carbonate of sodium, filtered from the carbonate of lead, and the cinnamic acid is precipitated by dilute sulphuric acid, in silvery lustrous laminæ, which are washed, and recrystallised from alcohol (Herzog). Dumas and Péligot dissolve the crystalline deposit from oil of cinnamon in boiling water, and evaporate the filtrate to the crystallising point.

b. From Liquid Storax.—Liquid storax is distilled with water and $\frac{1}{5}$ to $\frac{7}{10}$ pts. of crystallised carbonate of sodium, whereupon styrol passes over. The residual aqueous liquid is filtered from the resin; and the filtrate is mixed at first with just so much sulphuric acid, that a very small quantity of cinnamic acid is precipitated along with dissolved resin; and the liquid filtered from this precipitate is treated with excess of sulphuric acid, which precipitates cinnamic acid of a tolerably white colour. It is dissolved in a large quantity of water, with as little carbonate of sodium as possible, and again precipitated, first with a little sulphuric acid, and then, after the filtration, with an excess of acid, by which a white precipitate is formed. This is washed with water, dried, and dissolved in alcohol, which, by spontaneous evaporation, yields quite white and very large crystals (E. Simon). Erdmann and Marchand purify the acid by distillation, pressure between paper moistened with alcohol, and repeated crystallisation. D. Howard (Chem. Soc. Qu. J. xiii. 72) finds that cinnamic acid prepared from liquid storax contains a small quantity of benzoic acid, from which, however, it is purified by crystallisation from alcohol.

c. From Balsam of Peru.—When the slimy residue which deposits in Peruvian balsam by keeping, is dissolved in warm alcohol, and the filtrate is placed in a tall and narrow cylinder with a layer of water on the top, crystals of nearly pure cinnamic acid separate in a few days from the clear brown liquid (Herberger). When Peruvian balsam is boiled with thick milk of lime, the liquid filtered, the residual magma exhausted three or four times with boiling water, and the solution again filtered, the filtrate deposits on cooling, loose, almost white masses of crystals; and these, when decomposed by hydrochloric acid, yield nearly pure cinnamic acid, which may be obtained perfectly pure, either by distillation, or by solution in ammonia, filtration, and precipitation while hot by hydrochloric acid (E. Kopp). Simon proceeds as with storax.

d. From Balsam of Tolu.—Balsam of Tolu is boiled six or seven times with solutions of carbonate of sodium, which are taken continually weaker (the last extracts only contain a little benzoic acid, produced by the action of the alkali on the resin); and the alkaline decoctions are strongly concentrated by evaporation, and precipitated hot by hydrochloric acid, whereupon most of the cinnamic acid melts into a brown resin, and but little crystallises out on cooling. The latter is pressed, the resin is pulverised, and both are dissolved in ammonia diluted with 2 pts. of water, and heated to 80° C. The greater part of the resin then remains dissolved. The liquid is filtered; the residue is boiled with water; and the whole of the very brown liquids are evaporated and decomposed, while boiling, by hydrochloric acid, whereupon most of the acid again melts, while the remainder seprates out on cooling in nearly white crystalline scales, which are pressed, and washed with a little cold water. The melted acid is also washed with a little water. The whole of the acid is heated in a porcelain dish covered with paper till the water is expelled — very little acid subliming even at 200° C.— and the fused residue is bruised and distilled. Pure cinnamic acid then passes over as a colourless, clear, strongly refracting liquid, which solidifies to a white crystalline mass like stearin. Towards the end, yellowish vapours arise, which, when collected in another receiver, solidify into a mass of acid, which is contaminated by the presence of the empyreumatic oils of the resin, but may be obtained quite pure by recrystallisation from boiling water. (E. Kopp.)

Properties.—Cinnamic acid crystallises in colourless prisms or laminæ belonging to the monoclinic system. Ordinary combination, $\infty P . [\infty P\infty] . [P\infty]$. Ratio of orthodiagonal, clinodiagonal, and principal axis = 0·3674 : 1 : 1·1694. Inclination of clinodiagonal to principal axis = 82° 58′. Cleavage perfect parallel to $[\infty P\infty]$. Specific gravity of crystals = 1·195.

Cinnamic acid dissolves sparingly in cold water, easily in boiling water, alcohol, and ether; water precipitates it from the alcoholic solution. It melts at 129° C., and boils without decomposition at 293° (Dumas and Péligot), at 300°—304° (E. Kopp), with or without decomposition, according to the manner in which it is heated. If enclosed in a sealed tube, it may be heated to 200° C. (in a paraffin-bath) for several hours without alteration. (Howard.)

Decompositions.—1. Cinnamic acid, when slowly distilled, is resolved into cinnamene and carbonic anhydride: $C^9H^8O^2 = C^8H^8 + CO^2$, a small quantity of stilbene, $C^{14}H^{12}$, being likewise produced, and passing over with the cinnamene (Howard).—2. On red-hot platinum-foil, or in the flame of a candle, it burns with a smoky flame (Bizio). On red-hot charcoal, it evaporates without flame producing a strong biting smoke.—3. Strong *sulphuric acid*, or *sulphuric anhydride*, converts it into sulpho-cinnamic acid.—4. Cinnamic acid heated with excess of *iodine*, melts to a dark brown mass; and when this mass is heated with water, and the excess of iodine expelled by evaporation, iodocinnamic acid crystallises out on cooling (Herzog).—5. *Bromine* passed over cinnamate of silver forms bromocinnamic acid (Herzog).—6. *Chlorine* passed in diffused daylight over dry cinnamic acid, forms a tough greasy substance, which, when heated with carbonate of potassium, forms chlorocinnamate of potassium, and deposits a white oil containing chlorine (Herzog). The same products are formed when chlorine is passed into warm aqueous cinnamic acid or cinnamate of sodium, and when cinnamic acid is distilled with hypochlorite of calcium (Stenhouse, E. Kopp), or with chlorate of potassium and hydrochloric acid.—7. Strong *nitric acid* converts cinnamic acid into nitrobenzoic acid, provided the mixture be kept cool; otherwise nitrous fumes are evolved, and hydride of benzoyl is first obtained, then benzoic and nitrobenzoic acids. The same products are formed on heating cinnamic acid with more dilute nitric acid. — 8. Boiled with *peroxide of lead* in aqueous solution, cinnamic acid gives off the odour of bitter-almond oil, while the peroxide of lead assumes a light yellow colour, and is partially converted into benzoate of lead. This behaviour serves to distinguish cinnamic acid from benzoic acid (Stenhouse).—9. Cinnamic acid distilled with *sulphuric acid* and *acid chromate of potassium*, yields oil of bitter-almonds (Simon).—10. With *pentachloride of phosphorus* (also the trichloride, according to Béchamp), it yields chloride of cinnamyl (Cahours).—11. Fused with *hydrate of potassium*, it gives off hydrogen, and forms acetate and benzoate of potassium, a small quantity of salicylate of potassium being also produced by the action of potash on the benzoic acid previously formed (Chiozza):

$$C^9H^8O^2 + 2KHO = C^2H^3KO^2 + C^7H^5KO^2 + H^2.$$

Cinnamic acid is not decomposed by boiling with strong caustic potash (Simon).—12. In the dry distillation of the alkaline cinnamates or of cinnamic acid with *caustic baryta* or *lime*, a carbonate is formed, together with cinnamene and benzene.—13. Cinnamate of calcium, distilled with *formate of calcium*, yields cinnamic aldehyde (Piria. The reactions 6, 7, and 8, serve to distinguish cinnamic acid from benzoic acid.

AMATES.—Cinnamic acid is monobasic. the formula of its salts being $C^9H^7MO^2$.
crystallisable, and bear considerable resemblance to the benzoates. The
tes of the alkali-metals are easily soluble in water; those of the earth-metals
y metals sparingly soluble, the least soluble being the silver-salt. They dis-
re readily in water containing chlorides or nitrates.

olutions of most cinnamates yield a precipitate of cinnamic acid when decom-
the stronger acids. Cinnamates are decomposed by dry distillation, giving
lour of bitter-almonds. With strong *nitric* acid, they turn yellow, and give off
r of oil of cinnamon and bitter-almond oil. They likewise yield bitter-almond
distilled with *chromic* acid. With *ferric* salts, they give a yellow precipitate,
h *manganous* salts, the cinnamate being in excess, a white precipitate which
omes yellowish and crystalline. Benzoates give a reddish precipitate with
lts, and none with manganous salts. The cinnamates have been investigated
y Herzog (J. pr. Chem. xxix. 51), and E. Kopp (Compt. rend. liii. 634).

mate of Aluminium.—Loose white powder, sparingly soluble in cold, easily in
r.

mate of Ammonium, $2C^9H^7(NH^4)O^2$ + aq.—Sparingly soluble in cold water:
ammonia when melted, yielding a crystalline sublimate and a resinous residue.
cess of cinnamic acid, it forms an acid salt still less soluble in water. (Herzog.)

mate of Antimony and Potassium is deposited from a mixture of cinnamate
sium and tartar-emetic, in delicate hydrated crystals, which redissolve if left
g time in the liquid. The salt yields by calcination, a colourless residue,
fervesces with acids, and is coloured orange-red by sulphuretted hydrogen.
g.)

mate of Barium, $C^{18}H^{14}Ba''O^4$ + aq.—Precipitate, soluble in boiling water,
sing on cooling. Gives off its water at 110° C. (Herzog.) According to
, the salt forms broad, irregular, transparent, nacreous laminæ containing
$a''O^4$ + 2aq., becomes anhydrous at 140° C., and when distilled with excess of
hydrate, yields nearly pure cinnamene.

mate of Calcium, $C^{18}H^{14}Ca''O^4$ + 2aq.—Very little soluble in cold water,
boiling water, whence it separates in light crystalline masses (Herzog).—
$a''O^4$ + 3aq. White shining needles composed of thin nacreous laminæ, having
n of nearly rectangular parallelograms. It gives off one-third of its water
posed to the air at ordinary temperatures, and the rest at 150° C. (E. Kopp.)

mate of Cobalt.—Rose-coloured precipitate, soluble in alcohol. (Herzog.)

mate of Copper, $C^{18}H^{14}CaO^4.xCu''H^2O^2$.—The greenish-blue precipitate obtained
le decomposition, is a highly hydrated basic salt. When heated, it loses its
lour and decomposes, giving off cinnamic acid and cinnamene, and leaving
copper mixed with charcoal.

mates of Iron.—Both the *ferric* and *ferrous* salts are yellow precipitates,
y soluble in water. (Herzog.)

mate of Lead, $C^{18}H^{14}Pb''O^4$.—Granular crystalline powder, anhydrous and in-
in water (Herzog). Sometimes obtained in laminæ flattened or elongated
dles, and in small hard rounded grains (E. Kopp). Alcohol extracts a portion
innamic acid, leaving a basic salt.

mate of Magnesium, $C^{18}H^{14}Mg''O^4$ + 3aq., crystallised in the cold, forms small
eedles, which quickly become opaque on being exposed to the air. From a
solution it separates in tufts of shining needles, formed by the superposition
gated laminæ, very thin, and of nacreous aspect. It melts at 200° C. and be-
nhydrous.

anous Cinnamate, $C^{18}H^{14}Mn''O^4$ + 2aq.—Yellowish-white crystalline precipi-
ich dissolves in boiling water acidulated with acetic acid, and separates there-
shining yellowish laminæ, superposed on one another. (E. Kopp.)

rous Cinnamate.—White curdy precipitate.

mate of Nickel.—Green precipitate soluble in alcohol.

mate of Potassium, $2C^9H^7KO^2$ + aq.—Crystals belonging to the monoclini
giving off their water at 120°C, and decrepitating when strongly and suddenl
It is very soluble in water, but less so than the benzoate; moderately soluble
ol (Herzog). From a rather strong boiling solution containing excess of caustic
it crystallises readily in nacreous needles, which are anhydrous. (E. Kopp.)
cinnamic acid is dissolved in a hot solution of cinnamate of potassium, a
y soluble *acid salt* is deposited on cooling. (Herzog.)

mate of Silver, $C^9H^7AgO^2$.—White curdy precipitate, becoming crystalline
while; not much altered by light. It is insoluble in boiling water, but dis-
lightly in the liquid from which it has been precipitated (Herzog). White
ate, or silky nacreous needles composed of small elongated laminæ, often
ed. (E. Kopp.)

Cinnamate of Sodium, $2C^9H^7NaO^2 + aq.$—Crystals with dull surface, which give off their water at 110° C. (Herzog). The anhydrous salt, $C^9H^7NaO^2 + 2aq.$, crystallises in crusts surmounted with tufts of small needles, or in compact nodules. From a solution in weak caustic soda, it crystallises in beautiful needles containing ½ at. water of crystallisation. In strong caustic soda, it dissolves but sparingly at common temperatures, separating in hard, yellowish, radiated, anhydrous spheres. (E. Kopp.)

Cinnamate of Strontium, $C^{18}H^{14}Sr''O^4 + 4aq.$, when recently crystallised, forms white, nacreous, nearly opaque needles, composed of very small prisms. It is much more soluble in hot than in cold water; gives off 1 at. water when exposed to dry air, and the rest at 140° C. (E. Kopp.)

Cinnamate of Tin.—The *stannic* salt is a white precipitate. (Herzog.)

Cinnamate of Uranyl.—Yellow precipitate, sparingly soluble in boiling water. (Herzog.)

Cinnamate of Zinc.—Cinnamic acid dissolves zinc at the boiling heat, with evolution of hydrogen. The salt is moderately soluble, and crystallises by evaporation (Herzog).—$C^{18}H^{14}Zn''O^4 + 2aq.$ White precipitate, which dissolves in boiling water, and crystallises therefrom in shining, transparent, prismatic needles, sometimes grouped like mushrooms. (E. Kopp.)

CINNAMIC ETHERS. *Cinnamate of Ethyl*, $C^{11}H^{12}O^2 = C^9H^7(C^2H^5)O^2$. (Herzog, Arch. Pharm. [2] xvii. 72.—Marchand, Ann. Ch. Pharm. xxxii. 270.—E. Kopp, J. pr. Pharm. [3] xi. 72.—Plantamour, Ann. Ch. Pharm. xxx. 345).—This compound is easily obtained by distilling a mixture of 4 pts. absolute alcohol, 2 pts. cinnamic acid, and 1 pt. sulphuric acid, cohobating the product several times, agitating with water the oil which remains in the retort, and rectifying over massicot. It is a limpid liquid, of specific gravity 1·3, boiling at 262° C. (Herzog); at 266°, when the correction is made for the column of mercury projecting above the retort (H. Kopp). Vapour-density = 6·537 at 291° C. (by calculation for 2 vol. = 6·101).

Cinnamate of ethyl is nearly insoluble in water, but dissolves readily in alcohol and in ether. It is scarcely attacked by fuming nitric acid. Alkaline hydrates easily convert it into alcohol and a cinnamate of the alkali-metal.

Cinnamate of Methyl, $C^{10}H^{10}O^2 = C^9H^7(CH^3)O^2$ (E. Kopp, Compt. rend. xxi. 1376).—Obtained by saturating a mixture of cinnamic acid and wood-spirit with hydrochloric acid gas at a gentle heat, precipitating the product with water, then drying and rectifying. It is a colourless, oily liquid, having an agreeable aromatic odour. Specific gravity 1·106. Boiling point 241° C.

Cinnamate of Benzyl, or *Cinnamein* (p. 982).

Cinnamate of Cinnyl, $C^{18}H^{16}O^2 = C^9H^7O(C^9H^9)O$. *Cinnamyl-styrone*, *Styracin*. (Bonastre, J. Pharm. June, 1831, p. 338.—E. Simon, Ann. Ch. Pharm. xxxi. 365.—E. Kopp, Compt. chim. 1850, p. 140.—Toel, Ann. Ch. Pharm. lxx. 1.—Strecker, *ibid.* lxx. 40; lxxiv. 112.—Plantamour, *ibid.* xxvii. 239; xxx. 341.—Gössmann, *ibid.* xcix. 376.—Scharling, *ibid.* xcvii. 90, 174.—Gm. xiii. 286.—Gerh. iii. 403.)—This compound, which bears to cinnylic alcohol or styrone (p. 992) the same relation that acetate of ethyl bears to common alcohol, is contained in liquid storax (p. 497), together with cinnamic acid, styrol, and several resins; also in balsam of Peru.

Preparation from Storax.—1. The balsam is distilled with water to expel the styrol, and then boiled with aqueous carbonate of sodium, which extracts the free cinnamic acid. The residue thus obtained is a resinous spongy mass, which contains oily styracin in its pores, and when kneaded with the fingers becomes more and more compact, while the oily styracin runs out.—2. Toel dries the resinous cake which remains after boiling the liquid storax with carbonate of sodium, after it has been freed from the solution of cinnamate of sodium; macerates it repeatedly with cold alcohol, which extracts the colouring resin, and leaves most of the styracin but little coloured; and obtains the styracin quite pure by repeated crystallisation from ether-alcohol.—3. Wolff allows the resinous cake to stand for some time in cold alcohol, when it soon becomes crystalline; frees the crystals from resin by dissolving them in boiling alcohol, and precipitating the resin with acetate of lead; and frequently recrystallises, first from ether-alcohol, then from ether.—4. After distilling liquid storax with water, and repeatedly boiling the residue with carbonate of sodium, the undissolved portion is slowly allowed to cool to 30°—40°: the mass then becomes tough and spongy, and a yellow oil collects in its pores. This oil made to run out by kneading and pressing, and then filtered, solidifies after some time into a crystalline mass, which is purified by recrystallisation from alcohol. The residual mass still contains much styracin, and is therefore worked up for styrone (E. Kopp).—5. The residue left after distilling liquid storax with water, separates when repeatedly boiled with carbonate of sodium, into a solid dark resin, and liquid styracin. The latter is poured off, transferred to a flask, which is placed in an oil-bath at the temperature of 180° C., and distilled by passing steam heated to 180° through it; it then passes over as a white milky oil, which, when freed r, solidifies on standing in open vessels, to a faintly coloured crystalline mass, y be recrystallised from alcohol (Scharling).—8. Liquid storax is mace- ligested at a temperature not exceeding 30° C. with 5 to 6 pts. of dilute soda- e residue becomes colourless; this residue is collected, washed, dried and in alcohol containing ether; and from the solution, which, if not colourless, endered so by treatment with animal charcoal, pure styracin crystallises out. nn.)

ties.—Cinnamate of cinnyl, or styracin, crystallises in tufts of beautiful prisms, of taste and odour, insoluble in water, sparingly soluble in cold alcohol, very ether. It melts at 44° C. (Toel, Scharling), at 38° (E. Kopp), and re- uid and viscous for a long time after cooling. It distils without decomposi- eam heated to 180° C. (Scharling.)

ting storax as above described, styracin is sometimes obtained in a liquid, lisable state, especially if it has been left too long in contact with acids to m the last traces of soda.

positions.—Styracin in contact with caustic alkalis solidifies to a mass of ated granules. When distilled with potash, especially with strong alcoholic is decomposed like other compound ethers, yielding cinnylic alcohol (styrone) amate of potassium:

$$\underset{\text{Cinnamate of cinnyl.}}{\left.\begin{matrix}C^9H^7O\\C^9H^9\end{matrix}\right\}O} + \begin{matrix}H\\H\end{matrix}O = \underset{\text{Cinnylic alcohol.}}{\left.\begin{matrix}C^9H^9\\H\end{matrix}\right\}O} + \underset{\text{Cinnamic acid.}}{\left.\begin{matrix}C^9H^7O\\H\end{matrix}\right\}O.}$$

ith *nitric acid* it yields hydride of benzoyl, hydrocyanic acid, benzoic acid, benzoic acid. With *chromic acid*, it yields hydride of benzoyl, benzoic acid, sin. With a mixture of *sulphuric acid and peroxide of manganese*, it yields of benzoyl. With *strong sulphuric acid*, it yields cinnamic acid and a brown e, soluble in water, insoluble in saline solutions.

Substitution-derivatives of Cinnamic Acid.

OCINNAMIC ACID. $C^9H^7BrO^2$.—This acid is obtained by passing bromine n excess over cinnamate of silver, treating the decomposed salt with ether, orating the filtered solution. A thick oil then remains, which dissolves par- potash, and the alkaline solution decomposed by hydrochloric acid deposits of bromocinnamic acid. The portion of the oil insoluble in potash is probably le of carbon.

ocinnamic acid decomposes partially when dissolved in water and evaporated. easily soluble salts with all bases, and does not precipitate nitrate of silver. g.)

ROCINNAMIC ACID. $C^9H^7ClO^2$. (E. Kopp, J. Pharm. [3] xvi. 426.—Toel, Pharm. lxx. 7.)—Obtained: 1. By passing chlorine into a cold solution of acid in concentrated carbonate of sodium (Kopp).—2. By the action of alco- ash on an alcoholic solution of chlorostyracin, a chlorinated oil and chloride of n being formed at the same time. The mixture soon solidifies to a pulp, washed with alcohol, pressed, dissolved in a small quantity of boiling alcohol, ed with excess of hydrochloric acid. Chlorocinnamic acid then crystallises ooling, and may be purified by recrystallisation.

cid crystallises in long shining odourless needles, melting at 132° C., and sub- t a higher temperature. Its vapour excites coughing. It is sparingly soluble water, melts in boiling water, dissolves easily in alcohol and ether.

ocinnamate of Ammonium, $2C^9H^6Cl(NH^4)O^2$ + aq., forms curved arbores- edles. The *potassium-salt* forms lustrous pearly flakes. The *barium-salt*, BaO^2 + aq., is precipitated as a white powder, soluble in boiling water, and sing therefrom in shining laminæ. The *calcium-salt* is sparingly soluble, and s the barium-salt. The *silver-salt*, $C^9H^6ClAgO^2$, is obtained by precipitation solutions, in slender needles which blacken on exposure to light.

ocinnamate of Cinnyl or *Chlorostyracin*. $C^{18}H^{12}Cl^4O^2$.—Chlorine converts sty- o a viscid substance, having an acrid taste and an odour like that of copaiba It is insoluble in water, soluble in boiling alcohol and ether, whence it sepa- the amorphous state. It is decomposed by potash, yielding a chlorinated oil, nnamate of potassium, and chloride of potassium. Distilled in a current of , it forms a volatile chlorinated liquid and a crystallisable chlorinated acid, the which also crystallise readily. (E. Kopp.)

OCINNAMIC ACID. $C^9H^7(NO^2)O^2$. (Mitscherlich, Ann. Ch. Phys. [3] iv. Kopp, Compt. chim. 1849, p. 146; Compt. rend. liii. 634.—J. Wolff, Ann. Ch. lxxv. 303.)—This acid is produced by the action of strong nitric acid on cinnamic acid (Mitscherlich, Kopp), or by heating styrone with nitric acid, to which urea is added to prevent formation of nitrous acid (Wolff). To prepare it, concentrated nitric acid is freed from nitrous acid by boiling, and after cooling, about one-eighth of cinnamic acid is added. The cinnamic acid dissolves in a few minutes without disengagement of gas, the liquid becomes heated to 40° C., and a mass of crystals is deposited. In order to obtain larger quantities, cinnamic acid is triturated with nitric acid and cooled, so that the temperature may not rise above 50°; the mass is washed with cold water, till all nitric acid is removed, then dissolved in boiling alcohol and filtered; and the resulting crystals are washed with cold alcohol (Mitscherlich). Kopp dissolves 1 pt. of powdered cinnamic acid in 3 pts. of monohydrated nitric acid freed from nitrous acid by passing a dry stream of air through it, the mixture then solidifying almost immediately, in consequence of the crystallisation of the nitrocinnamic acid; washes the magma with water; then dries, and sets it aside for twenty-four hours with 4 pts. of cold alcohol, which removes any benzoic acid that may be present.

The acid forms very small white crystals, with a faint yellowish tint. It melts at about 270° C., and solidifies to a mass of crystals on cooling; boils a little above 270°, with decomposition. It is nearly insoluble in cold water, and dissolves but sparingly in boiling water; 1 pt. of it dissolves in 327 pts. of absolute alcohol at 20° C. Boiling hydrochloric acid dissolves it without decomposition (Mitscherlich.) With *sulphide of ammonium* it forms carbostyril. When it is dissolved in alcoholic sulphide of ammonium, sulphur separates on gently warming the liquid, while a yellow resin and an alkaloïd remain dissolved. Nitrocinnamic acid may be boiled with excess of alkali without decomposition.

Nitrocinnamic acid is but a feeble acid; nevertheless it forms neutral salts, and decomposes alkaline carbonates. The nitrocinnamates of the alkali-metals are very soluble, the rest are insoluble or sparingly soluble; they deflagrate when quickly heated, especially the potassium- and sodium-salts.

Nitrocinnamate of Ammonium gives off its ammonia when evaporated to dryness; its solution precipitates the salts of calcium, strontium, and magnesium when they are concentrated, but not when they are dilute.

Nitrocinnamate of Barium, $C^{18}H^{12}(NO^2)^2Ba''O^4 + 3aq.$, crystallises from a boiling solution on cooling, in stellate groups of yellowish needles. The *strontium-salt*, $C^{18}H^{12}(NO^2)^2Sr''O^4 + 5aq.$, may be obtained in small yellowish crystals grouped in nodules; it is moderately soluble in cold water. The *calcium-salt*, $C^{18}H^{12}(NO^2)^2Ca''O^4 + 3aq.$, forms small yellowish white agglomerated grains having a crystalline aspect. The *magnesium-salt*, $C^{18}H^{12}(NO^2)^2Mg''O^4 + 6aq.$, crystallises in yellowish white nodules, which dissolve with tolerable facility in water, especially if warm.

Nitrocinnamate of Copper.—Bluish-white precipitate, which becomes darker when air-dried. When mixed with sand and distilled, it yields benzoic acid, nitrocinnamene having the odour of oil of cinnamon, and a small quantity of nitrobenzene.

Mercuric Nitrocinnamate, $C^{18}H^{12}(NO^2)^2Hg''O^4$, is thrown down from boiling solutions of mercuric chloride and an alkaline nitrocinnamate, as a brownish anhydrous precipitate. The mother-liquors deposit on cooling a crystalline mass of very light bulky arborescent tufts, consisting of the double salt, $Hg''Cl^2.C^{18}H^{12}(NO^2)^2Hg''O^4 + 3aq.$

Nitrocinnamate of Potassium. $C^9H^6(NO^2)KO^2$.—Very soluble; crystallises in mamellated groups by spontaneous evaporation. From solution in boiling alkaline ley, it crystallises in prismatic needles. The *sodium-salt* resembles the potassium-salt.

Nitrocinnamate of Silver. $C^9H^6(NO^2)AgO^2$.—Yellowish white insoluble precipitate, which, when cautiously heated, decomposes with projection of the silver.

NITROCINNAMIC ETHERS.—The *ethyl-compound*, $C^{11}H^{11}NO^4 = C^9H^6(NO^2)(C^2H^5)O^2$, is formed by heating nitrocinnamic acid with alcohol and sulphuric acid (Mitscherlich, J. pr. Chem. xxii. 194), or by the action of strong nitric acid on cinnamate of ethyl (E. Kopp, Compt. rend. xxiv. 615). It crystallises in prisms, which melt at 136° C.; boils with decomposition at 300°. Potash at the boiling heat converts it into alcohol and nitrocinnamate of potassium.

Nitrocinnamate of Methyl. $C^{10}H^9NO^4 = C^9H^6(NO^2)(CH^3)O^2$. (E. Kopp, Compt. rend. liii. 636.)—Obtained by heating nitrocinnamic acid with methylic alcohol, mixed with a small quantity of sulphuric acid or saturated with hydrochloric acid gas. The mixture thickens at first, then liquefies again, and finally a brown liquid is obtained, from which the ether separates as a crystalline mass, which may be purified by pressure and recrystallisation from alcohol. It forms white, delicate, rather elongated needles, sparingly soluble in cold alcohol and ether, and having but little odour; melts at 161° C. to a colourless liquid, which solidifies in a crystalline mass on cooling. At about 200° C. it begins to sublime in iridescent crystalline plates, and at 200° it boils. It dissolves in alcoholic sulphydrate of ammonium, forming a red liquid, which afterwards turns brown, and when heated yields an abundant crystallisation of sulphur.

AMIC ALCOHOL. See CINNYLIC ALCOHOL.

AMIC ALDEHYDE. See CINNAMYL, HYDRIDE OF.

AMIC ANHYDRIDE. $C^{18}H^{14}O^3 = (C^9H^7O)^2.O$. *Cinnamate of Cinnamyl.*
Cinnamate, Anhydrous Cinnamic Acid. (Gerhardt, Ann. Ch. Phys. [3]
35.)—Produced by the action of oxychloride of phosphorus on well dried cin-
f sodium, the best proportions being 1 pt. of the former to 6 pts. of the latter.
uct is washed with water and carbonate of sodium, then dried and dissolved
; alcohol. It may also be obtained by the action of chloride of cinnamyl on
xalate of potassium. It crystallises from the alcoholic solution as a white
e substance, composed of microscopic needles. It is insoluble in cold alcohol,
lves but slightly even in boiling water, becoming acid at the same time. It
127° C.

-CINNAMIC ANHYDRIDE. $C^2H^3O.C^9H^7O.O$. See ACETIC ANHYDRIDE (p. 21).

CINNAMIC ANHYDRIDE. $C^7H^5O.C^9H^7O.O$. See BENZOIC ANHYDRIDE (p. 558).

CINNAMIC ANHYDRIDE. $C^{18}H^{12}N^2O^7 = [C^9H^6(NO^2)O]^2.O$. (Chiozza, Ann.
. [2] xxxix. 231.—Gerh. iii. 388.)—Produced by the action of oxychloride
horus on nitrocinnamate of potassium. It melts in boiling water more easily
ocinnamic acid, forming a yellow kneadable resin. It easily takes up water,
nverted into nitrocinnamic acid. With ammonia, it easily forms nitrocinna-
nitrocinnamate of ammonium. With alcohol, it forms nitrocinnamate of ethyl.
ringly soluble in ether.

AMIC ETHERS. See page 986.

AMIDE. $C^9H^9NO = N.H^2.C^9H^7O$.—Chloride of cinnamyl treated with dry
, yields sal-ammoniac, together with a white substance which dissolves in
lcohol, and separates in delicate needles in cooling. (Cahours.)

CINNAMIDE. $C^9H^8N^2O^3 = N.H^2.C^9H^6(NO^2)O$. (Cahours, Ann. Ch. Phys. [3]
52.)—Prepared: 1. By the action of aqueous ammonia on the product ob-
y treating nitrocinnamate of potassium with oxychloride of phosphorus. After
s digestion at a gentle heat, the reaction is complete, and the nitrocinnamic
le is completely transformed into nitrocinnamide and nitrocinnamate of am-
which remains in solution. The nitrocinnamide is collected on a filter and
by crystallisation from boiling water.—2. By the action of alcoholic ammonia
innamate of ethyl; this process, however, takes a long time, and requires a
antity of alcohol.

innamide separates from solution in boiling water in shortened, lustrous
sometimes in grains and laminæ having the appearance of flies' wings. It
d turns brown between 155° and 160 C., and decomposes completely at 260°.
ves sparingly in cold alcohol, moderately in ether, and separates from solution
g alcohol in small, very regular, hemispherical concretions, smooth in the
nd nodular in the lower part. It dissolves in caustic potash, producing a red
without evolution of ammonia.

YL-CINNAMIDE. *Cinnanilide.* $N.H.C^6H^5.C^9H^7O$. (Cahours, Ann. Ch. Phys.
i. 344.)—Produced by the action of phenylamine on chloride of cinnamyl.
ves easily in hot alcohol, and separates in slender needles on cooling. It melts
ntle heat, and distils completely at a higher temperature. Potash-solution
attacks it, even with aid of heat; but when fused with hydrate of potassium,
off phenylamine.

NISYL-CINNAMIDE. *Cinnitranisidine.* $C^{16}H^{14}N^2O^4 = N.H.C^7H^6(NO^2)O.C^9H^7O$.
ced by the action of chloride of cinnamyl on nitranisidine (p. 304). Yellowish
sparingly soluble in cold, more soluble in boiling alcohol. (Cahours.)

ANILIDE. Syn. with PHENYL-CINNAMIDE (*vid. sup.*)

HYDRAMIDE. $C^{27}H^{24}N^2 = N^2(C^9H^8)^3$.—A compound produced by the
of ammonia on hydride of cinnamyl. It is analogous to hydrobenzamide,
², and is therefore more properly called hydrocinnamide (*q. v.*)

AMON, OIL OF, and **OIL OF CASSIA.** These oils, which are nearly
l in composition, are obtained from the bark of different trees of the genus
onum, order *Lauraceæ*, viz. oil of cinnamon from Ceylon cinnamon, *Cinnamo-
ylanicum;* and oil of cassia, from the bark of Chinese cinnamon, *Cinnamomum
cum*, or from *cassia buds*, the undeveloped flowers of *Cinnamomum Lauresii*
The oils are prepared by softening the bruised bark or flowers with salt water,
g quickly, and drying with chloride of calcium. Oil of cinnamon has a more
le odour than oil of cassia, and is therefore more esteemed.

the oils consist mainly of cinnamic aldehyde, which may be separated by means
id sulphite of alkali-metal (p. 991); also a hydrocarbon, not yet examined, in
, but always very small quantity, together with cinnamic acid, and resins.

Old samples often deposit crystals of cinnamic acid. The density of the oils varies from 1·025 to 1·05; their boiling point from 220° to 225° C.

Resins from Cinnamon-oil.—Old samples of the oil are more or less coloured and charged with resinous matters, which remain, after the oil has been distilled with salt water, the residue treated with cold water, to extract the salt, and afterwards with boiling water, to extract cinnamic acid. According to Mulder (Ann. Ch. Pharm. xxxiv. 149), there are two resins formed in the oil by atmospheric oxidation; one, α, soluble in cold alcohol, melting at 60° C., and containing 78·33 per cent. carbon, 6·49 hydrogen, and 15·18 oxygen: the other, β, sparingly soluble only in hot alcohol, melting at 145°, and containing 83·45 per cent. C, 6·06 H, and 10·49 O.

Mulder likewise describes several other resins, some soluble, others insoluble in alcohol, produced by treating oil of cinnamon with sulphuric acid, hydrochloric acid, and ammonia: they have all nearly the same composition as the β-resin, produced by atmospheric oxidation. (Gm. xiii. 264.)

CINNAMON-STONE. A variety of garnet (*q. v.*)

CINNAMYL. C^9H^7O.—The monatomic radicle of cinnamic acid and its derivatives. The following is a list of its compounds, and of those of the derived radicles, chlorocinnamyl, &c.

Type HH:	
Chloride of Cinnamyl	$C^9H^7O.Cl$
Cyanide of Cinnamyl	$C^9H^7O.Cy$
Hydride of Cinnamyl: *Cinnamic Aldehyde*	$C^9H^7O.H$
Hydride of Tetrachlorocinnamyl: *Chlorocinnose*	$C^9H^3Cl^4O.H$
Type HHO:	
Hydrate of Cinnamyl: *Cinnamic Acid*	$C^9H^7O.H.O$
Hydrate of Bromocinnamyl: *Bromocinnamic Acid*	$C^9H^6BrO.H.O$
Hydrate of Chlorocinnamyl: *Chlorocinnamic Acid*	$C^9H^6ClO.H.O$
Hydrate of Nitrocinnamyl: *Nitrocinnamic Acid*	$C^9H^6(NO^2)O.H.O$
Oxide of Cinnamyl: *Cinnamic Anhydride*	$(C^9H^7O)^2O$
Oxide of Cinnamyl and Acetyl: *Aceto-cinnamic Anhydride*	$C^9H^7O.C^2H^3O.O$
Oxide of Cinnamyl and Benzoyl: *Benzo-cinnamic Anhydride*	$C^9H^7O.C^7H^5O.O$
Oxide of Nitrocinnamyl: *Nitrocinnamic Anhydride*	$[C^9H^6(NO^2)O]^2O$
Type NH^3:	
Cinnamide	$N.H^2.C^9H^7O$
Phenyl-cinnamide: *Cinnanilide*	$N.H.C^6H^5.C^9H^7O$
Nitranisyl-cinnamide: *Cinnitranisidine*	$N.H.C^7H^6(NO^2)O.C^9H^7O$

The compounds of cinnamyl are intimately related to those of benzoyl, C^7H^5O, and are easily converted by oxidising reagents into hydride of benzoyl and benzoic acid. Cinnamic acid heated with excess of hydrate of potassium, is resolved, with evolution of hydrogen, into acetic and benzoic acids (p. 984).

CINNAMYL, CHLORIDE OF. $C^9H^7O.Cl$. (Cahours, Ann. Ch. Phys. [3] xxiii. 341.—Béchamp, Compt. rend. xlii. 224.)—This compound is produced by the action of trichloride or pentachloride of phosphorus on cinnamic acid. When the pentachloride is used, the product is distilled, the portions which pass over between 250° and 265° C. being collected apart and rectified (Cahours). With the trichloride, the mixture must be heated to between 60° and 120° C., as long as hydrochloric acid continues to escape. It then melts and forms two layers, the upper of which, consisting of chloride of cinnamyl, is decanted and distilled. (Béchamp.)

Chloride of cinnamyl is a heavy oil, of specific gravity 1·207, boiling at 262° C. In a moist atmosphere it decomposes quickly, yielding hydrochloric acid and fine crystals of cinnamic acid. In contact with alcohol, it becomes strongly heated, and if water be then poured upon the mixture, cinnamate of ethyl separates as a heavy oil. With ammonia and phenylamine, it yields cinnamide and phenyl cinnamide respectively. Heated with cinnamate of sodium, it yields cinnamic anhydride.

CINNAMYL, CYANIDE OF. $C^{10}H^7NO = C^9H^7O.Cy$. (Cahours, *loc. cit.*)—Produced by distilling chloride of cinnamyl with cyanide of potassium or cyanide of mercury. A liquid then passes over, which rapidly turns brown when exposed to the air, yielding hydrocyanic and cinnamic acids. It still contains chlorine, but consists for the most part of cyanide of cinnamyl.

CINNAMYL, HYDRIDE OF. $C^9H^8O = C^9H^7O.H$. *Cinnamic Aldehyde.* (Dumas and Péligot, Ann. Ch. Phys. lvii. 305.—Mulder, Ann. Ch. Pharm. xxxiv.

ertagnini, *ibid.* lxxxv. 272.—**Gm.** xiii. 258.—**Gerh.** iii. 373.)—This com- rms the essential part of oil of cinnamon or oil of cassia, and may be sepa- erefrom by the action either of nitric acid or of the acid sulphites of the etals.

ien commercial oil of cinnamon is shaken up with strong nitric acid, large are formed, after two or three hours, consisting of a compound of nitric acid namic aldehyde, which, when collected on a filter, so as to allow the still liquid to drain off, and then decomposed by water, yields pure cinnamic aldehyde. s and **Péligot.**)

of cinnamon is agitated with three or four times its volume of a solution of hite of potassium of 28°—30° Bm; and the crystalline mass, which forms in a ites, is separated from the mother-liquor, left to dry on a filter, then pulverised, with cold alcohol, again dried, and dissolved at a gentle heat in dilute sul- cid. A large quantity of sulphurous acid is then given off, and the cinnamic e rises to the surface as an oil, which may be purified by washing and drying. mic aldehyde is a colourless oil rather heavier than water. It may be distilled decomposition, either in vacuo, or with water which has been freed from air by When exposed to the *air*, it quickly becomes yellow and resinous, and ac- n acid reaction. It rapidly absorbs *oxygen* gas, especially if moist, and is converted into cinnamic acid. Heated with *nitric acid*, it forms benzoic acid lride of benzoyl. *Chromic* acid converts it into benzoic and acetic acids z). Boiled with solution of *hypochlorite of calcium*, it yields benzoate of Strong *sulphuric acid* converts it into a resinous mass.

mic aldehyde gradually heated in a stream of *chlorine*, forms at first a liquid id, which solidifies when treated with a strong solution of potash. When dis- ur or five times in a stream of chlorine, it is converted into tetrachlorocinnamyl. *ntachloride of phosphorus*, it yields hydrochloric acid and chloride of cinnamyl. ith *hydrate of potassium*, it forms cinnamate of potassium, with evolution of n:

$$C^9H^8O + KHO = C^9H^7KO^2 + H^2.$$

ia-gas converts it into cinnhydramide:

$$3C^9H^8O + 2NH^3 = C^{27}H^{24}N^2 + 3H^2O.$$

Compounds of Cinnamic Aldehyde.

ith Hydrochloric Acid.—Oil of cinnamon absorbs a large quantity of hydro- acid gas, acquiring a green colour and becoming thicker. 100 pts. of the oil 26·9 pts. of hydrochloric acid.

ith Iodine and Iodide of Potassium.—When cinnamon-water is placed in con- h iodine and iodide of potassium and cooled to 0° C., a crystallisable compound, ^{6}.KI, is formed. It crystallises from alcohol and ether, but water decomposes ng free the cinnamic aldehyde. An excess of iodide of potassium prevents the osition. (**Apjohn**, Ann. Ch. Pharm. xxviii. 314.)

ith Nitric Acid. $C^9H^8O.HNO^3$.—Produced when strong nitric acid is left in with cinnamic aldehyde. It forms oblique, rhomboïdal prisms, often two or iches long. After being drained, they may be preserved for some hours, but t rise of temperature or atmospheric humidity quickly decomposes them. When with water, they yield pure cinnamic aldehyde.

ite of cinnamic aldehyde kept in an imperfectly closed vessel, yields after a few red liquid, which has the characteristic odour of bitter-almond oil, is converted ionia-gas into nitrate of ammonium and a red resin; and is dissolved by strong ic acid, the solution yielding with water a precipitate of cinnamic acid.

ith Acid Sulphites of Alkali-metals.—Cinnamic aldehyde dissolves easily in s acid sulphite of ammonium, forming an oily liquid, which afterwards solidifies stalline pulp. Oil of cassia shaken up with a strong solution of acid sulphite of ium soon solidifies to a yellow crystalline mass, which may be purified from the arbon and other substances which the oil contains, in addition to cinnamic al- , by washing with alcohol of 80 or 90 per cent. (**Gössmann**). The compound unstable, quickly turning brown, even when kept in closed vessels.

potassium-salt is obtained by agitating oil of Ceylon or Chinese cinnamon with r four times its volume of a solution of acid sulphite of potassium of 28° to n.; after washing with alcohol and recrystallisation from boiling alcohol, it beautiful silvery plates nearly inodorous and permanent in the air. It is soluble water, but the solution is decomposed by heat, giving off sulphurous acid and g colourless drops of cinnamic aldehyde. Heated in a test-tube, it gives off sulphurous acid, and cinnamic aldehyde, which, by contact with the air, is con- into cinnamic acid. Bromine and iodine dissolve in the aqueous solution without colouring it, but converting the sulphurous acid into sulphuric acid, and setting free the cinnamic aldehyde. Bromine in excess produces a solid, slightly aromatic substance fusible in hot water.

Sodium-salt.—Oil of cinnamon mixed with solution of acid sulphite of sodium of 37° Bm. forms a crystalline fibrous substance, which, if left to itself, soon becomes completely liquid; at the same time there is formed an oil which is not solidified, either by acid sulphites of alkali-metal or by nitric acid, the sulphite of cinnamyl-sodium apparently remaining dissolved. The liquid, if left to evaporate, yields crystals of sulphate of sodium, together with opaque crystalline nodules, which dissolve in boiling alcohol, forming a solution which on cooling deposits long thin needles arranged in spiral groups. (Bertagnini.)

HYDRIDE OF TETRACHLOROCINNAMYL. *Chlorocinnose.* $C^9H^3Cl^4O.H$. (Dumas and Péligot, Ann. Ch. Phys lvii. 316.)—By repeatedly distilling hydrate of cinnamyl in chlorine gas, this compound is obtained in long white very volatile needles. It melts at a gentle heat and sublimes without decomposition. It is soluble in alcohol. It is not decomposed by strong sulphuric acid, even at the boiling heat, and may be volatilised without alteration in a current of dry ammonia.

The formation of this substance is preceded by that of several liquid compounds, one of which, perhaps *hydride of monochlorocinnamyl*, solidifies in contact with potash-ley.

CINNYL. C^9H^9.—The radicle of the compound usually called *cinnamic* alcohol or *styrone*. Cinnyl bears to cinnamyl, C^9H^7O, the radicle of cinnamic acid, the same relation that ethyl, C^2H^5, bears to acetyl, C^2H^3O.

CINNYLIC ALCOHOL. $C^9H^{10}O = C^9H^9.H.O$. *Hydrate of Cinnyl, Cinnamic Alcohol, Styrone, Styracone, Styrax-Alcohol, Styrylic Alcohol, Peruvin.* (E. Simon, Ann. Ch. Pharm. xxxi. 274.—Toel, *ibid.* lxx. 3.—Strecker, *ibid.* lxx. 10.—J. Wolff, *ibid.* lxxxv. 299.—E. Kopp, Compt. chim. 1850, p. 113.—Scharling, Ann. Ch. Pharm. cxv. 90, 183.—Gm. xiii. 256.—Gerh. iii. 402.)—This compound is obtained by cautiously distilling styracin with a strong solution of caustic potash or soda. A milky liquid then passes over, from which, when saturated with common salt, a creamy substance separates, gradually collecting on the surface in an oily layer and solidifying (Toel). Wolff dissolves styracin in boiling alcoholic potash; mixes water with the liquid; filters from cinnamate of potassium; and separates the precipitated cinnamic alcohol from undecomposed styracin by distillation.

Cinnylic alcohol forms beautiful soft silky needles, having a sweet taste and an agreeable odour of hyacinths. It melts at 33° C., and volatilises without alteration at a higher temperature. It is moderately soluble in water, very soluble in alcohol, in ether, in styrol, and in oils, both fixed and volatile. When the aqueous solution saturated at the boiling heat is left to cool, it becomes milky, and does not clarify for several hours, when it becomes filled with needle-shaped crystals.

CIPOLINO. A white marble with shadings or zones of green talc, found in Italy.

CISSAMPELINE. Syn. with PELOSINE (*q. v.*)

CITRACONAMIDES and **CITRACONANILIDES.** See AMIDES OF CITRACONIC ACID (p. 993).

CITRACONIC ACID. *Pyrocitric Acid.* $C^5H^6O^4$. (Lassaigne [1822], Ann. Ch. Phys. xxi. 100.—Dumas, *ibid.* cxi. 21.—Robiquet, *ibid.* lxv. 78.—Liebig, Ann. Ch. Pharm. xxvi. 119, 152.—Crasso, *ibid.* xxxiv. 68.—Engelhardt, *ibid.* lxx. 246.—Gottlieb, *ibid.* lxxvii. 265.—Baup, Ann. Ch. Phys. [3] xxxiii. 192.—Gm. x. 417.—Gerh. ii. 120.)—This acid, or rather its anhydride, is produced by the dry distillation of citric acid, constituting in fact the chief portion of the distillate (p. 995). The anhydride rapidly attracts moisture, and when exposed to the air, is converted into a crystalline mass of citraconic acid, which is freed from excess of water by pressure between blotting-paper and exposure to a temperature of 50° C. Citraconic acid is also one of the products of the dry distillation of lactic acid.

Citraconic acid is inodorous, and has a sour and slightly bitter taste. It crystallises in four-sided prisms, dissolves in 8 pts. of water at 10° C., and is readily soluble in alcohol and in ether. It melts at 80° C.; small quantities of it kept for some time at 100° are converted into itaconic acid. By dry distillation it is resolved into citraconic anhydride and water.

When citraconic acid is heated with strong *nitric acid*, a violent reaction is set up, accompanied by disengagement of gas, and an oily body is produced, which on cooling solidifies to a crystalline mass, consisting of two crystalline nitro-compounds, eulyte and dyslyte, which dissolve in alcohol to an unequal extent; their composition is not known. By *dilute nitric acid*, citraconic acid is converted into *mesaconic acid*.

When *bromine* is gradually added to a strong solution of citraconate of potassium, carbonic acid is disengaged and a heavy yellowish oil separates, consisting of an acid and a neutral substance. The former is removed by treatment with dilute potash, which

e latter unaltered. When a weak acid is added to the alkaline solution, there is
d, sometimes a heavy oil and sometimes fine needles. These two bodies are iden-
omposition, and consist of an acid, $C^4H^6Br^2O^2$, which has been named by Ca-
s discoverer, *bromotriconic acid*. It has the composition of dibrominated butyric
693); but Cahours did not obtain it by the action of bromine on butyric acid
ate of potassium. The liquid acid is slightly amber-coloured, and has a pecu-
ır. When distilled, it gives off hydrobromic acid and leaves a carbonaceous
The liquid acid, after standing for some time, occasionally solidifies to a mass
als. When it is heated with concentrated potash, a peculiar odour is disen-
nd the addition of an acid no longer precipitates an oil. The acid forms a
ecipitate with silver-solution, and its ammonium-salt crystallises.

eutral oil formed in the preparation of the acid has the composition $C^3H^3Br^3O$,
either be *tribromopropionic aldehyde* or *tribrominated acetone*.

e action of *bromine* on citraconate of potassium, in presence of excess of
of potassium, an oil is also separated and carbonic acid disengaged. When
olution of potash is added, the greater part dissolves, and a small quantity
omopropionic aldehyde remains; on adding dilute nitric acid to the alkaline
large white crystalline flakes are deposited, consisting of an acid which crys-
rom alcohol and ether in long prisms. It has the composition of dibromo-
c acid, $C^5H^4Br^2O^2$, but Cahours names it bromitonic acid.

ACONATES.—Citraconic acid is a dibasic acid, and forms two series of salts,
neutral salts, $C^5H^4M^2O^4$ and $C^5H^4M''O^7$, and *acid salts*, $C^5H^5MO^2$ and
$''O^8$; they are isomeric with the itaconates, mesaconates, and lipates. The
s mostly crystallise well.

cid barium-salt, $C^{10}H^{10}Ba''O^8$, crystallises in large groups of fine silky needles.

eutral silver-salt, $C^5H^4Ag^2O^4$, crystallises both anhydrous and with an
water. In an aqueous solution of citraconic acid, nitrate of silver produces,
ion of ammonia, a very bulky precipitate which dissolves in boiling water.
ng, the salt is deposited in long needles. If the mother-liquor from this be
vaporated, hexagonal crystals are formed which have an adamantine lustre, and
of the hydrated salt, $C^5H^4Ag^2O^4 + H^2O$.

cid silver-salt, $C^5H^5AgO^4$, is obtained by dissolving the neutral salt in an
ution of citraconic acid. On evaporation, large groups of crystals are obtained.

aconate of Ethyl, or *Citraconic Ether*, $C^9H^{14}O^4$, is obtained by repeatedly
ing a mixture of alcohol, citraconic acid, and hydrochloric acid, and washing the
e with water.

a colourless, bitter, somewhat aromatic liquid, of density 1·040 at 18°·5 C. It
225° C. with partial decomposition. It is insoluble in water, but readily soluble
ol and in ether. In contact with water, it gradually acidifies and alcohol is
By potash it is decomposed into citraconate of potassium and alcohol. E. A.

RACONIC ACID, AMIDES OF:

ACONAMIDE, $C^5H^8N^2O^2 = N^2.H^4.(C^5H^4O^2)''$, is obtained as a yellow viscid
hich becomes brittle and vitreous on cooling, when citraconic anhydride is
n a stream of dry ammoniacal gas. It dissolves in water, and the solution on
yields citraconate of ammonium. It is derived from neutral citraconate of am-
by the loss of 2 at. of water:

$$C^5H^4(NH^4)^2O^4 - 2H^2O = C^5H^8N^2O^2.$$

ACONIMIDE. $C^5H^5NO^2 = N.H.(C^5H^4O^2)''$.— Citraconic acid is mixed with
f ammonia and evaporated to dryness, and the residue heated to 180° C. An
ous oily yellow mass is left, which is citraconimide. It does not dissolve in cold
nd but slightly so in alcohol; it is highly hygroscopic. It is derived from
aconate of ammonium by the loss of 2 at. of water:

$$C^5H^5(NH^4)O^4 - 2H^2O = C^5H^5NO^2.$$

ylcitraconimide or *Citraconanil*. $C^{11}H^9NO^2 = N.C^6H^5.(C^5H^4O^2)''$.—When
ous citraconic acid is mixed with phenylamine, a brisk action ensues, and the
, if kept for some time in the water-bath, is totally converted into the above
nd. It crystallises in colourless needles, which melt at 96° C., and sublime at
above 100°. It is readily soluble in alcohol and in ether.
derived from acid citraconate of phenylamine by the loss of 2 at. of water:

$$C^5H^5(C^6H^7N)O^4 - 2H^2O = C^{11}H^9NO^2.$$

henylcitraconimide, $C^{11}H^8INO^2$, is obtained by substituting iodophenylamine in
ve reaction.

rophenylcitraconimide, $C^{11}H^7(NO^2)^2NO^2$, is obtained by the action of a mixture
and sulphuric acid on phenylcitraconimide.

Citraconamic Acid. $C^5H^7NO^3 = N.H^2.\overbrace{C^5H^4}^{\prime\prime\prime}\overbrace{O^2.H}^{\prime\prime}.O$.—Citraconimide appears to be partially convertible into this acid by boiling with ammonia. Its salts are uncrystallisable.

Phenylcitraconamic Acid, $C^{11}H^{11}NO^3 = N.H.\overbrace{C^6H^5.C^5H^4}^{\prime\prime\prime}\overbrace{O^2.H}^{\prime\prime}.O$, is obtained as an ammonium-salt by boiling phenylcitraconimide with dilute ammonia. On the addition of acetic acid, it is separated as a crystalline precipitate, which is washed with cold water. It is an unstable body. It is derived from acid citraconate of phenylamine by the loss of an atom of water:

$$C^5H^5(C^6H^8N)O^4 - H^2O = C^{11}H^{11}NO^3.$$

Dinitrophenylcitraconamic acid, $C^{11}H^9(NO^2)^2NO^3$, is obtained in a similar manner.
E. A.

CITRACONIC ANHYDRIDE. $C^5H^4O^3$.—This compound is produced by the dry distillation of citric acid, constituting the greater part of the crude product. On rectifying this crude distillate, two layers are formed, the upper being aqueous, and the lower an oily acid liquid which does not solidify. This, which is citraconic anhydride, is purified by redistillation. The same substance is formed by heating itaconic acid.

Citraconic anhydride is a colourless inodorous liquid of specific gravity 1·247. It rapidly absorbs ammonia, with disengagement of heat, forming a vitreous deliquescent mass, which probably consists of citraconamic acid. E. A.

CITRACONIC CHLORIDE. *Pyrocitric Chloride, Chloride of Pyrocitryl.* $C^5H^4O^2Cl^2$.—When pentachloride of phosphorus is mixed with citraconic anhydride, a brisk action ensues, and on subsequent distillation, oxychloride of phosphorus passes over, followed by chloride of pyrocitryl when the temperature has reached 175° C. It contains, however, some citraconic anhydride, which raises the boiling point; it is freed therefrom by redistillation with pentachloride of phosphorus, the part distilling between 175°—190° being ultimately collected. It is a highly refracting fuming liquid, with a density of 1·4. With water, it forms citraconic and hydrobromic acids, and with absolute alochol, citraconic ether and hydrochloric acid. E. A.

CITRACONIC ETHER. See CITRACONATES (p. 993).

CITRAMIDES. See page 1000.

CITRACONIMIDE (p. 993).

CITRACONIODANIL. Syn. with IODOPHENYLCITRACONIMIDE (p. 993).

CITRENE. *Citronyl.* $C^{10}H^{16}$.—A liquid isomeric with oil of lemon, &c., obtained by distilling the solid di-hydrochlorate of lemon-oil over hydrate of potassium or quick lime. It is transparent and colourless, of specific gravity 0·8569. vapour-density 4·73 (by calculation for 2 vol. 4·71); boils at 165° C. It resembles oil of lemon in most of its properties, and in forming a crystallisable compound with hydrochloric acid, but differs from it in being without action on polarised light. (Gm. xiv. 303.)

CITRIC ACID. $C^6H^8O^7 = C^6H^5O^4.H^3.O^3$. (Scheele [1784], *Opuscula* ii. 181.—Berzelius, Ann. Chim. xciv. 171; Ann. Ch. Phys. lii. 424, 432; lxvii. 303; lxx. 215.—Robiquet, *ibid.* lxv. 68.—Liebig, Ann. Ch. Pharm. v. 134; xxvi. 119, 452; xliv. 57.—Marchand, J. p. Chem. xxiii. 60.—Cahours, Ann. Ch. Phys. [3] xix. 488.—Pebal, Ann. Ch. Pharm. lxxxii. 78; xcviii. 67.—Gm. xi. 436.—Gerh. ii. 85.)—The existence of a peculiar organic acid in the juice of lemons and of oranges has long been known, but the discovery of the separate identity of this acid, and its discrimination from tartaric acid, was first effected by Scheele in 1784, who gave to it the name it bears.

It is to the presence of citric acid that a great many fruits owe their acidity. This acid occurs in the free state in oranges, lemons, citrons, tamarinds, cherries, currants, gooseberries, raspberries, strawberries, whortleberries, and a great many others. In some of them it is associated with malic and tartaric acids. It is also contained in several tubers and bulbs, such as the potato and the onion. Occasionally it occurs as acid potassium or calcium salt.

Preparation.—The raw material for the production of citric acid is lemon juice. The juice is made to undergo an incipient fermentation; it is then filtered and neutralised, first with chalk and afterwards with quick lime, by which an insoluble citrate of calcium is formed: 10 pts. of this salt are carefully decomposed by a cold mixture of 9 pts. sulphuric acid and 56 of water; the gypsum is washed with cold water; and the filtrate and wash-water are boiled down in a leaden vessel over the naked fire until the liquor has the specific gravity 1·13, then concentrated over a water-bath until a saline film begins to form, when the liquid is immediately cooled to the crystallising point; if it were further concentrated. the excess of sulphuric acid would convert the residue into a black mass. The crystals formed are purified by four or five recrys-tions, and the mother-liquors are utilised for the preparation of citric acid by nent with chalk, in the same manner as the fresh lemon juice. In the south ance, the citrate of calcium is bleached with chloride of lime, prior to its decomon with sulphuric acid. Good lemons yield about 5½ per cent. of the crystallised

e raw material generally used in this country for the preparation of citric acid e large scale, for the use of calico-printers, is a black fluid, like thin treacle, a comes from Sicily, and is obtained by inspissating the expressed juice of the n after the rind has been removed for the sake of the essential oil. (*Ure's Dicry of Arts, Manufactures and Mines*, i. 690.)

tric acid may also be prepared from gooseberries. Tilloy (J. Pharm. xiii. 305) esses the juice of the unripe berries; leaves it to ferment; distils off the alcohol ed; filters the residual liquid; and treats it with chalk in the same manner as in reparation of the acid from lemon juice. 100 pounds of gooseberries give 10 pounds irit of specific gravity 0·928, and 1 pound of crystallised citric acid.

operties.—Citric acid crystallises in two forms. A concentrated solution deposits pontaneous evaporation, large, transparent, colourless prisms, having the composi- $C^6H^8O^7 + H^2O$; this is the ordinary commercial acid. The crystals belong to rimetric system, and generally have the faces $\infty P . \bar{P}\infty . \breve{P}\infty$ predominant, also $\infty P\infty$; the face $2\breve{P}\infty$ likewise occurs together with $\bar{P}\infty$, and sometimes without P also not unfrequently occurs subordinate. Ratio of brachydiagonal, macrodial, and principal axis = 0·6068 : 1 : 0·4106. (*Kopp's Krystallographie*, p. 264; lso Gerh. ii. 88.) The crystals effloresce in the air between 28° and 50° C., lose their water of crystallisation at 100°. A boiling concentrated solution of acid allowed to cool, deposits crystals of a different form, which, according to some nists, contain $2C^6H^8O^7 + H^2O$; according to others, this water is only mechanically d.

tric acid has a strong, but pleasant, acidity, in which respect it differs from tar- acid, the acidity of which is accompanied by a somewhat bitter taste. This difce is still greater in the salts.

tric acid is soluble in 0·75 pts. of cold and in 0·5 pts. of boiling *water*. It is ly soluble in *alcohol*, but insoluble in *ether*.

tric acid and its potassium-salt are used in medicine. It is also used in the pretion of effervescent summer beverages. Its most extensive application is in dyeing calico-printing; for certain of the finer colours, it cannot be replaced by less costly .

hen *lime-water* is added to a solution of citric acid, a slight precipitate is formed, e solution is concentrated and the lime-water present in great excess. But if the ure be boiled, a considerable precipitate of citrate of calcium is formed, which relves as the solution cools. By this deportment, free citric acid is easily detected. distinguished from tartaric and racemic acids by the fact that its potassium-salt luble.

compositions.—1. Solution of citric acid, when kept for some time, becomes covered fungi.—2. An aqueous solution mixed with chalk and exposed for some time to a erature of 20°—30° C. in contact with a little *yeast*, yields acetic and butyric acids. rding to How, when exposed in contact with *putrefying curd* and a base, it ferts and becomes converted into acetic and propionic acids.—3. When citric acid is ed in a retort, it first melts in its water of crystallisation and then boils, giving off water, which condenses in the receiver. Afterwards at about 175° C. vapours of one distil over, and a copious disengagement of carbonic oxide takes place. At this , the residue in the retort consists of aconitic acid. If the distillation be coned, carbonic acid is given off and oily striæ begin to appear in the neck of the retort, h solidify to crystals of itaconic acid. If these last crystals be repeatedly disd, an oily mass of anhydrous citraconic acid is obtained, which no longer solidi- These decompositions of citric acid are thus expressed:

$C^6H^8O^7$ Dry citric acid.	$-$	H^2O	$=$	$C^6H^6O^6$. Aconitic acid.
$C^6H^6O^6$ Aconitic acid.	$-$	CO^2	$=$	$C^5H^6O^4$. Crystallised itaconic acid.
$C^5H^6O^4$ Crystallised itaconic acid.	$-$	H^2O	$=$	$C^5H^4O^3$. Citraconic anhydride.

The acetone and carbonic oxide observed in an earlier stage of the decomposition are probably due to a secondary decomposition of aconitic acid, thus:

$$\underset{\text{Aconitic acid.}}{C^6H^6O^6} = 2CO^2 + CO + \underset{\text{Acetone.}}{C^3H^6O}.$$

Heated with *pumice*, citric acid gives off carbonic anhydride at 153° C.—4. Fused with *potash*, citric acid is decomposed into oxalic and acetic acids:

$$\underset{\text{Citric acid.}}{C^6H^8O^7} + H^2O = \underset{\text{Oxalic acid.}}{C^2H^2O^4} + \underset{\text{Acetic. acid.}}{2C^2H^4O^2}.$$

5. When citric acid is treated with strong *sulphuric acid*, a disengagement of carbonic oxide ensues, even without the application of heat. But if the temperature be raised, the odour of acetone is perceived, and carbonic anhydride is given off. On adding carbonate of sodium to the residual liquid diluted with water, a brown resinous mass is precipitated, and the solution contains the sodium-salt of a peculiar acid, which does not precipitate baryta or strontia. — 6. Citric acid is not attacked by dilute *nitric acid;* but if heated for some time with strong nitric acid, it yields oxalic and carbonic acids.

7. Citric acid is easily oxidised by *permanganic acid.* A solution of citric acid mixed with sulphuric acid does not decolorise *permanganate of potassium* in the cold; but at 80° C. the citric acid is oxidised to carbonic acid and acetone:

$$2C^6H^8O^7 + H^2O + O^{10} = C^3H^6O + 9CO^2 + 6H^2O.$$

If a large excess of the permanganate be used, other products are likewise formed, namely, a body which strongly irritates the eyes and respiratory organs, reduces permanganate of potassium at common temperatures, and is turned brown by alkalis, probably therefore acrolein, together with an acid closely analogous to acrylic acid. Finely divided peroxide of manganese acts in the same way as the permanganate. (Péan de Saint Gilles, Ann. Ch. Phys. [3] lv. 374.)

8. *Chlorine* acts but feebly on citric acid. When a layer of concentrated solution of citric acid is exposed to the sunlight in a large globe filled with chlorine, the gas is slowly absorbed, and an oil gradually separates, which after rectification is colourless, has a sweetish burning taste, and a peculiar odour. It boils at 200°—201° C., and does not solidify at 0°. It reddens litmus paper only after prolonged contact. Plantamour, the discoverer of this body, assigns to it the formula $C^5Cl^{10}O^2$; when it is agitated with water and cooled to + 6°, a mass of crystals is formed, $C^5Cl^{10}O^2.3H^2O$, which melt and give off their water at 15°. The oil is attacked by potash, with formation of a body, $C^4Cl^4K^2O^4$. Städeler considers the oil to be hexachlorinated acetone C^3Cl^6O (p. 30), and the crystals to be a hydrate, $C^3Cl^6O + H^2O$. Laurent ascribes to the oil the formula $C^5Cl^{10}O^2$.

9. The action of chlorine on citrate of sodium, though not very energetic even in sunshine, is different. Carbonic acid is disengaged, and the liquor becomes milky from formation of an oil; at the same time, an acid citrate of sodium is formed, which crystallises in stellate groups. The odour of the oil, at first sweetish, becomes gradually more acrid. It is a mixture of several bodies. On rectification, chloroform first distils over at 64°—66° C.; the boiling point then rises to 188°—190°, and remains constant for some time; it then rises to 200°, at which point the oil produced by the free acid distils over. The intermediate product, on rectification, boils at 190°. It is a colourless and very fluid oil, of specific gravity 1·66, with a burning taste, an extremely irritating odour, and exciting tears. It has the formula $C^5Cl^{10}O^2$. The action of alcoholic potash on this oil yields chloride of potassium, and a very soluble potassium-salt which crystallises in satiny scales; it has the formula $C^4Cl^4K^2O^4$. The same salt is produced by the action of potash on the oil from the free acid. A corresponding silver-salt is very unstable, and is readily reduced to the metallic state even in the cold. The potassium-salt has the composition of that of a chlorinated succinic acid. The mother-liquor from which the chlorinated oil has been deposited contains, besides chloride of sodium, the sodium-salt of an acid which has the composition of succinic acid but appears to be only isomeric with it.

10. When *bromine* is gradually added to solution of citrate of potassium, a brisk disengagement of carbonic acid takes place; and if the addition of bromine be continued as long as gas is given off, and the excess of bromine carefully removed by potash, an oil is precipitated which is a mixture of two bodies. The most volatile of these is bromoform, $CHBr^3$. The other has received from Cahours the name bromoxaform. It consists of lustrous silky needles, which by spontaneous evaporation crystallise in large colourless plates. They melt between 74° and 75° C., but are gradually decomposed by distillation. The formula of the body is $C^3HBr^5O^2$ (pentachlorinated pro-

acid): it is decomposed by potash, with formation of bromide of potassium, oxalic and bromoform:

$$\underset{\text{Bromoxaform.}}{C^3HBr^5O^2} + 2KHO = 2KBr + \underset{\text{Oxalic acid.}}{C^2H^2O^4} + \underset{\text{Bromoform.}}{CHBr^3}.$$

ried citric acid in contact with *pentachloride of phosphorus*, becomes heated, and oxychlorocitric acid and oxychloride of phosphorus:

$$C^6H^8O^7 + PCl^5 = C^6H^8O^6Cl^2 + POCl^3.$$

mixture be heated, hydrochloric acid is evolved, and chloride of citryl appears formed:

$$C^6H^8O^6Cl^2 + PCl^5 = \underset{\text{Chloride of citryl.}}{C^6H^5O^4Cl^3} + POCl^3 + HCl + H^2O.$$

heat be continued, the liquid assumes a deep cherry-red colour and then appears tain chloride of aconityl:

$$C^6H^5O^4Cl^3 + PCl^5 = \underset{\text{Chloride of aconityl.}}{C^6H^3O^3Cl^3} + POCl^3 + 2HCl.$$

rates. Citric acid is a strong acid. It reddens blue litmus paper and expels nic acid from carbonates. An aqueous solution dissolves zinc and iron, with disement of hydrogen.

ric acid is tribasic. It may be derived from 3 at. water in which 3 at. hydrogen placed by the triatomic radical citryl, $C^6H^5O^4$. It therefore forms three series ts, in which 1, 2, or 3 at. hydrogen are replaced by metal, thus:—

Citric acid	$\left.\begin{matrix}(C^6H^5O^4)'''\\ H^3\end{matrix}\right\}O^3$		
Acid monometallic citrate . .	$\left.\begin{matrix}(C^6H^5O^4)'''\\ H^2.M\end{matrix}\right\}O^3$	and	$\left.\begin{matrix}(C^6H^5O^4)^2\\ H^4M''\end{matrix}\right\}O^6$
Acid dimetallic citrate . . .	$\left.\begin{matrix}(C^6H^5O^4)'''\\ H.M^2\end{matrix}\right\}O^3$	and	$\left.\begin{matrix}(C^6H^5O^4)'''\\ HM''\end{matrix}\right\}O^3$
Neutral trimetallic citrate . .	$\left.\begin{matrix}(C^6H^5O^4)'''\\ M^3\end{matrix}\right\}O^3$	and	$\left.\begin{matrix}(C^6H^5O^4)^2\\ M''^3\end{matrix}\right\}O^6$

ne of the citrates occur naturally, as citrate of calcium in onions and potatoes, itrate of potassium in artichokes and potatoes. The alkaline citrates are very e; other citrates, as those of zinc, iron, cobalt and nickel are less so, while the es of the alkaline earths are insoluble. In the presence of soluble citrates, alkalis t precipitate the salts of iron, manganese, or aluminium. The citrates decompose heated to 230°C., forming empyreumatic products, which have not been investigated. e following list includes all the principal citrates.

TRATE OF ALUMINIUM.—Insoluble powder when it contains excess of metal; e gum when the acid is in excess.

TRATE OF AMMONIUM. *Monammonic Citrate*, $C^6H^7(NH^4)O^7$.—Solution ric acid, neutralised with ammonia, and then mixed with twice as much acid as eady contains, yields this salt by spontaneous evaporation in small triclinic s.

ammonic Citrate, $C^6H^6(NH^4)^2O^7$, crystallises on the evaporation of a solution ric acid which has been saturated by ammonia, in prisms which are anhydrous but rescent.

TRATES OF BARIUM. *Tribarytic Citrate*, $C^{12}H^{10}Ba^3O^{14}$.—Citric acid added ess of baryta-water throws down flakes which become somewhat crystalline. White er; dried in the cold, it contains water of crystallisation, which it gives off comy at 200° C.

nobarytic Citrate?—Obtained as a gummy mass by evaporating a solution rytic citrate in citric acid.

rystalline citrate of barium which, dried at 160° C., has the formula $C^{24}H^{22}Ba^5O^{28}$, ained by adding tribarytic citrate to a boiling transparent mixture of citric acid hloride of barium, as long as the resulting precipitate redissolves, and then ng the mixture to cool. It appears to be a double salt of tribarytic and ytic citrate.

rate of sodium is precipitated only by a large excess of chloride of barium: citrate of barium must be somewhat soluble in citrate of sodium.

TRATE OF CADMIUM.—Crystalline sparingly soluble salt.

TRATES OF CALCIUM. *Tricalcic Citrate*, $C^{12}H^{10}Ca^3O^{14} + 4H^2O$.—When chloride of calcium is gradually added to a solution of citrate of sodium, the precipitate at first formed redissolves, but when agitated, it suddenly forms a magma which becomes crystalline on the application of heat. The salt is more soluble in cold than in hot water, so that a cold solution becomes turbid on being boiled.

The *dibasic salt*, $C^6H^6Ca''O^7 + H^2O$, is obtained in shining laminæ by dissolving the preceding compound in excess of citric acid, and evaporating the solution.

CITRATE OF CERIUM.—White insoluble powder, obtained by double decomposition of alkaline citrates and cerous salts.

CITRATE OF COBALT, $C^{12}H^{10}Co^3O^{14} + 14H^2O$.—The solution of carbonate of cobalt in warm citric acid, solidifies on cooling, after adequate evaporation, to a rose-coloured magma, which dries up to a powder of the same colour.

CUPRIC CITRATE.—Obtained in microscopic rhombohedra by heating a solution of cupric acetate with citric acid. The formula is $C^{12}H^{10}Cu^3O^{14}.Cu''H^2O^2 + 2H^2O$.

CITRATES OF IRON. *Ferrous Citrate.*—Alcohol precipitates white flakes of triferrous citrate from a clear solution of iron in citric acid.

Ferric Citrate.—Freshly precipitated hydrated ferric oxide dissolves in warm aqueous citric acid, forming a reddish-brown liquid which on evaporation leaves a light-brown film. It is administered medicinally under this form. Ferrocyanide of potassium does not precipitate an acid solution of ferric citrate, but forms a blue liquid which is decolorised by ammonia.

Ammonio-ferric Citrate. (Ammonio-citrate of iron.)—When 2 pts. of freshly precipitated ferric hydrate are dissolved in 3 pts. of citric acid, the solution saturated with ammonia leaves on evaporation a greenish-yellow mass, insoluble in strong alcohol, but soluble in alcohol of 40 per cent.

CITRATE OF LITHIUM.—Amorphous, limpid, hard mass.

CITRATES OF LEAD. *Triplumbic Citrate*, $C^{12}H^{10}Pb^3O^{14}$ (at 120° C.), is best obtained by precipitating an alcoholic solution of plumbic acetate with an alcoholic solution of citric acid, and washing the precipitate with alcohol; it is granular when hot solutions are employed.

Dibasic Salt. $C^6H^6Pb''O^7 + H^2O$.—A solution of acetate of lead is added to a boiling dilute solution of citric acid as long as the precipitate redissolves. On evaporating the clear solution, the salt crystallises in small prisms. Ammonia dissolves this salt, and the solution afterwards deposits triplumbic citrate.

Tetrabasic Salt.—By digesting triplumbic citrate with ammonia, Berzelius obtained a heavy white powder, which had the formula $C^{12}H^{10}Pb^3O^{14}.PbH^2O^2$. The triplumbic citrate digested with excess of subacetate of lead, gave an insoluble amorphous powder, which had the formula $C^{12}H^{10}Pb^3O^{14}.PbH^2O^2.2PbO$. Heldt obtained a salt of the formula $C^{12}H^{10}Pb^3O^{14}.2PbO + 3H^2O$, by digesting triplumbic citrate with ammonia for two days in a close vessel. Bulky, white, insoluble powder.

CITRATE OF MAGNESIUM. $C^{12}H^{10}Mg^3O^{14} + 14H^2O$.—Carbonate of magnesium dissolves in citric acid to a solution which forms a thick magma when concentrated. Alcohol precipitates the salt from its aqueous solution.

This salt, evaporated with excess of citric acid, yields a gummy mass, which does not become crystalline.

When carbonate of magnesium is digested with disodic citrate, the filtered solution on evaporation leaves small crystalline groups, which contain sodium and magnesium.

CITRATE OF MANGANESE. $C^{12}H^{10}Mn^3O^{14} + 2H^2O$.—Citrate of sodium does not precipitate manganous salts; but when carbonate of manganese is digested with citric acid, the above salt is obtained as a white insoluble crystalline powder.

CITRATES OF MERCURY.—Citric acid precipitates from *mercurous* acetate, a white powder soluble in nitric acid.

Freshly precipitated *mercuric oxide* dissolves in hot citric acid, and the solution on cooling deposits a white powder, which is decomposed by water.

CITRATE OF NICKEL. $C^{12}H^{10}Ni^3O^{14} + 14H^2O$.—Oxide of nickel dissolves in citric acid to a green liquid, gradually changing into a green jelly, which on evaporation leaves an olive-green film, soluble in water but precipitated by alcohol.

CITRATES OF POTASSIUM. *Tripotassic Citrate.* $C^6H^5K^3O^7 + H^2O$.—A solution of carbonate of potassium neutralised with citric acid, yields by spontaneous evaporation, transparent, stellate-grouped needles, very deliquescent, and insoluble in absolute alcohol. They lose their water of crystallisation at about 200° C.

Dipotassic Citrate. $C^6H^6K^2O^7$.—A solution of 2 pts. of citric acid neutralised with carbonate of potassium, and mixed with 1 pt. of citric acid, yields by evaporation an amorphous mass having a sour taste.

Monopotassic Citrate. $C^6H^7KO^7 + 2H^2O$.—1 pt. of citric acid is neutralised with potash, 1 pt. of citric acid added, and the mixture evaporated at 40° C. Large transparent prisms, permanent in the air, and having an agreeable sour taste. They melt in their water of crystallisation, and give off 13·8 per cent. of water, forming a viscous liquid, which solidifies on cooling to a concentric radiated mass of crystals, consisting of $C^6H^7KO^7$.

Ammonio-potassic Citrate. $C^6H^5K^2(NH^4)O^7$.—A solution of dipotassic citrate neutralised with ammonia, yields this salt, on evaporation, in transparent deliquescent prisms.

Potassio-antimonic Citrate.—1 pt. of citric acid is neutralised with potash; 1 pt. more of acid added; the mixture boiled for some time with trioxide of antimony, and the filtrate left to crystallise. White, shining, very hard prisms, grouped in tufts. They give off 6·7 per cent. of water at 190° C. May be regarded as a double molecule of tripotassic citrate, in which part of the potassium is replaced by the tribasic radicle, antimony: $C^{12}H^{10}(K^3Sb''')O^{14}$.

CITRATE OF SILVER. $C^6H^5Ag^3O^7$.—Citrate of potassium added to solution of nitrate of silver, throws down this salt as a heavy white powder, which crystallises from boiling water in white or yellowish needles. Deflagrates at a high temperature.

Argentous Salt.—The above salt heated to 100° C. in a current of hydrogen, is changed into a dark brown mass, which is a mixture of citric acid and triargentous citrate. Water extracts from this mass first citric acid, and then a small quantity of argentous salt with a red colour. This red solution heated to boiling, assumes a green and blue colour, then deposits metallic silver, and becomes decolorised.

CITRATES OF SODIUM. *Trisodic Citrate.* $2(C^6H^5Na^3O^7) + 11H^2O$.—When a solution of citric acid is saturated with soda, and the solution left to evaporate, large rhombic prisms are obtained of this composition. They quickly effloresce and are sparingly soluble in alcohol. At 100° C. 7 at. water are given off, and at 190°—200°, 4 at. more. A solution of this citrate evaporated at 60° C., yields monoclinic crystals containing only 2 at. water.

Disodic Citrate. $C^6H^6Na^2O^7.H^2O$.—Obtained like the corresponding potassium-salt. Prismatic, stellate-grouped crystals, which give off their water of crystallisation when dried over oil of vitriol.

Monosodic Citrate. $C^6H^7NaO^7 + H^2O$.—Obtained like the corresponding potassium-salt. A very concentrated solution left to evaporate in a warm place, solidifies to a mass of acicular crystals, and crystallises to the last drop.

Ammonio-sodic Citrate.—Confused crystalline crust.

Potassio-sodic Citrate. $C^6H^5Na^3O^7.C^6H^5K^3O^7 + 11H^2O$—Obtained by dissolving equivalent quantities of trisodic citrate and tripotassic citrate, and concentrating by evaporation. It is deposited after some days in radiate-grouped, lustrous needles.

CITRATE OF STRONTIUM.—Strontia-water is precipitated by citric acid in thick white flakes, which, after drying over oil of vitriol, have the composition $C^{12}H^{10}Sr^3O^{14} + 2H^2O$. They lose their water of crystallisation at 210° C.

CITRATE OF ZINC. $C^{12}H^{10}Zn^3O^{14} + 2H^2O$.—Carbonate of zinc dissolves readily in aqueous citric acid; on boiling, the salt is precipitated as a granular, crystalline powder. The aqueous solution of this salt mixed with a small quantity of citric acid, and evaporated at a gentle heat, deposits transparent crystals, which have the composition $C^{12}H^{10}Zn^3O^{14}.2C^6H^6ZnO^7 + 2H^2O$.

Substitution-derivative of Citric Acid.

OXYCHLOROCITRIC ACID. $C^6H^8Cl^2O^6 = \left.\begin{matrix}(C^6H^5O^4)'''\\ H^3\end{matrix}\right\}\begin{matrix}Cl^2\\ O^2\end{matrix}$.—When pentachloride of phosphorus is mixed with dry citric acid, the mass becomes heated, liquefies, and then solidifies to a magma of crystals which consist of oxychlorocitric acid mixed with oxychloride of phosphorus. The latter is removed by digestion with disulphide of carbon, the mass is thrown on a filter, and washed with disulphide, then pressed between bibulous paper, and dried in a current of hot air. It forms colourless silky needles:

$$C^6H^8O^7 + PCl^5 = C^6H^8O^6Cl^2 + POCl^3.$$

In moist air or in water, this acid becomes heated and is converted into citric acid.

On heating it in a stream of dry air to 100° C., hydrochloric acid is liberated, and the residue consists of aconitic acid. Dry ammonia acts violently upon it, forming a black vesicular mass. In contact with aniline, the acid becomes strongly heated, and yields phenyl-aconitimide. E. A.

CITRIC ACID, AMIDES OF. (Pebal, Ann. Ch. Pharm. lxxxii. 73; xcviii. 67.)—Of the amides of citric acid, bodies derived from ammonia by the replacement of hydrogen by the radicle citryl, only citramide is known; but many of the corresponding phenyl-compounds have been obtained by Pebal.

Citramide. $C^6H^{11}N^3O^4 = \left.\begin{matrix}(C^6H^5O^4)''' \\ H^3 \\ H^3\end{matrix}\right\} N^3$, is a crystalline compound, slightly soluble in water, obtained by the action of alcoholic ammonia on citrate of methyl or citrate of ethyl.

Phenylcitramide. Citranilide. $\left.\begin{matrix}(C^6H^5O^4)''' \\ (C^6H^5)^3 \\ H^3\end{matrix}\right\} N^3$, is obtained by the action of heat on triphenylamic citrate:

$$\underset{\text{Triphenylamic citrate.}}{C^6H^5(C^6H^8N)^3O^7} - 3H^2O = \underset{\text{Phenylcitramide.}}{C^{24}H^{23}N^3O^4}.$$

To prepare this body, the yellow powder left on heating triphenylamic citrate is dissolved in boiling alcohol, and the solution is decolorised by animal charcoal. On cooling, two sets of crystals are deposited, hexagonal plates and fine prisms. The former consist of phenylcitrimide, and are dissolved out by boiling with alkali, which does not perceptibly affect the phenylcitramide. Phenylcitramide is deposited from alcohol in colourless prisms, truncated longitudinarily, and with a nacreous lustre. Neutral to vegetable colours.

Phenylcitrimide. Citrobianil. $C^{18}N^2H^{14}O^4 = \left.\begin{matrix}(C^6H^5O^4)''' \\ (C^6H^5)^2 \\ H\end{matrix}\right\} N^2$, represents diphenylamic citrate *minus* 3 atoms of water:

$$\underset{\text{Diphenylamic citrate.}}{C^6H^6(C^6H^8N)^2O^7} - 3H^2O = \underset{\text{Phenylcitrimide.}}{C^{18}H^{16}N^2O^4}.$$

It is obtained in the preparation of phenylcitramide; also by heating phenylcitramic acid with phenylamine:

$$\underset{\text{Phenylcitramic acid.}}{C^{12}H^{11}NO^5} + \underset{\text{Phenylamine.}}{C^6H^7N} = \underset{\text{Phenylcitrimide.}}{C^{18}H^{16}N^2O^4} + H^2O.$$

Hexagonal plates, soluble in alcohol, and converted by boiling with ammonia into diphenylcitramic acid.

Phenylcitramic Acid. Citranilic Acid. $C^{12}H^{11}NO^5 = \left.\begin{matrix}N(C^6H^5)(C^6H^5O^4)''' \\ H\end{matrix}\right\} O$.—Obtained by the action of heat on monophenylamic citrate:

$$\underset{\text{Monophenylamic citrate.}}{C^6H^7(C^6H^8N)O^7} - 2H^2O = \underset{\text{Phenylcitramic acid.}}{C^{12}H^{11}NO^5}.$$

Monophenylamic citrate is heated to 140° — 150° C. as long as water is given off. On cooling, the residue becomes crystalline. It dissolves readily in water, and if excess of phenylamine has been avoided, it is deposited in small crystalline spherules, or in mamillary groups of small prisms. It has an acid reaction, and forms crystalline salts with silver and with aniline.

On treating it with pentachloride of phosphorus, hydrochloric acid is given off, and a liquid formed, which appears to contain *chloride of aconitanyl*, $C^{12}NH^8O^3.Cl$, as, when treated with water, it is resolved into hydrochloric acid and phenylaconitamic acid.

Diphenylcitramic Acid. Citrobianilic Acid. $C^{18}H^{18}N^2O^5$.—Obtained in the form of an ammonia-salt by boiling phenylcitrimide with ammonia. By adding hydrochloric acid to the solution, the acid is precipitated. Recrystallised from alcohol, it forms soft, concentrically-grouped, silky needles. It melts and gives off water at 150° C., and becomes reconverted into phenylcitrimide.

Diphenylcitramic acid contains the elements of diphenylamic citrate *minus* 2 at. water: $C^6H^6(C^6H^8N)^2O^7 - 2H^2O = C^{18}H^{18}N^2O^5$, and may be represented by the formula $\left.\begin{matrix}(C^6H^5)^2 \\ (C^6H^5O^4)''' \\ H^3\end{matrix}\right\} \begin{matrix}N^2 \\ O\end{matrix}$, derived from the mixed type $N^2H^6.H^2O$. E. A.

CITRIC ETHERS. The citric ethers represent citric acid in which one or more atoms of hydrogen are replaced by alcohol-radicles. Those in which one or two atoms of hydrogen are thus replaced have acid properties.

RAT[illegible] OF METHYL. *Trimethylic Citrate.* $C^9H^{14}O^7 = \left.\begin{matrix}(C^6H^5O^4)'''\\(CH^3)^3\end{matrix}\right\}O^3$.—
ion of citric acid in wood-spirit is saturated with hydrochloric acid gas; on recti-
the mixture, chloride of methyl and the excess of wood-spirit pass off, and a
ess liquid distils over at about 90° C., which is citrate of methyl. After standing
ime it crystallises. (Saint-Èvre, Compt. rend. xxi. 144.)

omethylcitric Acid, $\left.\begin{matrix}(C^6H^5O^4)'''\\H^2.CH^3\end{matrix}\right\}O^3$, and *Dimethylcitric acid,* $\left.\begin{matrix}(C^6H^5O^4)'''\\H.(CH^3)^2\end{matrix}\right\}O^3$,
th formed in the preparation of citrate of methyl. They have been but little
ed. (Demondesir, Compt. rend. xxxiii. 227.)

RATE OF ETHYL. *Citric Ether.* $\left.\begin{matrix}(C^6H^5O^4)'''\\(C^2H^5)^3\end{matrix}\right\}O^3$. (Thénard, Mém. d'Ar-
i. 12.—Malaguti, Ann. Ch. Phys. lxiii. 197.—Dumas, Compt. rend. viii. 528.—
nand, J. pr. Chem. xx. 318.—Heldt, Ann. Ch. Pharm. xlvii. 57.—Demon-
loc. cit.)—This body is formed by distilling a mixture of sulphuric acid, citric
nd alcohol; but the best method of preparing it, according to Demondesir, is as
: A solution of citric acid in alcohol is saturated with hydrochloric acid gas,
uid neutralised with carbonate of soda, and agitated with common ether, which
es out the citric ether. On evaporating the ethereal solution, citric ether is left
oily, yellowish, transparent liquid, with an odour resembling olive oil. Its spe-
avity is 1·142. It is very soluble in alcohol and in ether. It boils at 280° C.,
composes—probably into aconitic or citraconic ether. It is decomposed by free
into citrates and free alcohol. With ammonia it yields, besides citramide,
products which have not been examined. E. A.

RIDIC ACID. Syn. with ACONITIC ACID.

RILENE. See CITRENE.

RINE. A glassy variety of quartz having a wine-yellow colour.

RINS. *Citroglycerins. Citrates of Glyceryl.* (van Bemmelen, J. pr. Chem.
4.)—Two of these compounds have been obtained by heating citric acid with
n.

tral Citrate of Glyceryl, $C^9H^{10}O^7 = \left.\begin{matrix}(C^6H^5O^4)'''\\(C^3H^5)'''\end{matrix}\right\}O^3$, is prepared by heat-
ric acid with a slight excess of glycerin to 160°—170° C. for twenty hours.
then escapes, and there remains a hard, light yellow, transparent mass, from
the pure product may be obtained by boiling out the excess of glycerin with
. It is difficult to pulverise; insoluble in water, alcohol, and ether. Hydro-
acid dissolves it gradually with aid of heat; sulphuric acid immediately, with
ning. It dissolves gradually in cold potash-ley, and when boiled with bases, is
resolved into citric acid and glycerin. The formation of the compound is re-
ed by the equation:

$$\underset{\text{Citric acid.}}{C^6H^8O^7} + \underset{\text{Glycerin.}}{C^3H^8O^3} = C^9H^{10}O^7 + 3H^2O.$$

ic Citrate of Glyceryl. *Citrodiglyceride,* $C^{12}H^{18}O^{10} = C^9H^{10}O^7.C^3H^8O^3$,
regarded as a double molecule of glycerin $\left(\left.\begin{matrix}C^6H^{10}\\H^6\end{matrix}\right\}O^6\right)$, in which 3 at. hydro-
replaced by citryl, that is to say, as $\left.\begin{matrix}(C^6H^{10})^{vi}\\(C^6H^5O^4)'''\\H^3\end{matrix}\right\}O^6$.—Obtained like the pre-
by heating citric acid with a double quantity of glycerin. The mass melts at
, and the transformation is completed between 160° and 170°. The product
by boiling with alcohol, is yellowish-brown, somewhat darker and less hard
e neutral compound, which, however, it resembles in other respects.

ROCERIC and **CITROLIC ACIDS.** Two acids said to be contained in
iment of lemon and bergamot oils; the former is waxy, the latter oily. (My-
rch. Pharm. xxxii. 28.)

RODIANIL. Syn. with PHENYLCITRIMIDE (p. 998).

ROGLYCERIN. See CITRINS.

ROMANNITANS. (v. Bemmelen, Jahresber. f. Chem. 1858, p. 435.)—
rm is applied to two compounds derived from mannite in the same manner as
rins are derived from glycerin. They are formed by heating citric acid with
e in proper proportion to between 130° and 140° C., combination then taking
ttended with elimination of water.

Monocitromannitan. $C^{12}H^{14}O^{9} = \left.\begin{array}{c}(C^6H^6)^{iv}\\(C^6H^5O^4)'''\\H^3\end{array}\right\}O^6 = C^6H^8O^7 + C^6H^{14}O^6 - 3H^2O$.—A hard, light yellow, tasteless substance, insoluble in cold water, alcohol, and ether, decomposed by long boiling with water or alcohol, also by alkalis. Between 170° and 180° C. it turns brown and decomposes.

Dicitromannitan. $C^{18}H^{20}O^{16} = \left.\begin{array}{c}(C^6H^6)^{vi}\\(C^6H^5O^4)'''\\(C^6H^5O^4)'''\end{array}\right\}O^6 + 2H^2O$.—Obtained as a hydrate by heating 2 at. citric acid and 1 at. mannite for some time to between 140° and 150° C. The product is a dry, hard, light yellow mass, which has no acid reaction, dissolves in water only after long boiling, is easily decomposed by alkalis, and does not give off water without decomposition when heated.

CITRON, OIL OF. See CITRUS MEDICA (p. 1004).

CITRONYL. The name applied by Blanchet and Sell to that constituent of lemon-oil, which forms a crystallisable compound with hydrochloric acid (p. 1004). It is sometimes also applied to the triatomic radicle of citric acid.

CITROPTENE. The camphor or stearoptene of lemon-oil (p. 1004).

CITRUS. A genus of plants belonging to the natural order *Aurantiaceæ*, and including the orange, lemon, citron, shaddock, &c. They all produce juicy fruits containing citric acid, and enclosed in a thick fleshy rind containing volatile oils, which are isomeric with oil of turpentine, but differ from one another in odour, density, action on polarised light, &c.

CITRUS AURANTIUM. The *Sweet Orange.*—The rind of this fruit contains a volatile oil, *Oil of orange-peel, Oleum corticum aurantiorum*, which may be extracted by pressure or by distillation with water. It has the same composition and vapour-density as oil of lemon. Specific gravity in the liquid state 0·83—0·89. Boiling point 180° C. It is neutral, and has an agreeable odour. Optical rotatory power, 125·6°—127·4° to the right. It dissolves completely in absolute alcohol, and with turbidity in 7—10 pts. alcohol of specific gravity 0·85. It unites with hydrochloric acid, forming a liquid compound, $C^{10}H^{16}.HCl$, and a solid compound, $C^{10}H^{16}.2HCl$, which melts at 50° C. (Gm. xiv. 306.)

Orange-peel also contains, especially in the unripe state, a bitter principle called **Aurantiin** or **Hesperidin** (*q. v.*)

The **juice** of the orange contains citric and malic acids, partly free, partly combined with bases. The juice of sweet oranges likewise contains grape-sugar or cane-sugar; the grape-sugar predominates in the unripe state, but does not sensibly increase in quantity as the fruit ripens, while the amount of cane-sugar increases, both absolutely and relatively to the weight of the orange, the juice, and the solid constituents (Berthelot and Buignet, Compt. rend. li. 1094). 100 pts. of oranges contain 4·2 per cent. cane-sugar, 4·3 grape-sugar, and 0·45 free acid (Buignet, Ann. Ch. Phys. lxi. 233). The pips of the orange contain a bitter substance, which appears to be identical with the limonin of lemon-pips.

The **flowers** of the orange contain a very fragrant volatile oil, called *Oil of Neroli, Oleum florum naphæ s. neroli*, which is obtained by distilling the flowers with water. When recently prepared, it is nearly colourless, but reddens quickly on exposure to light. According to Soubeiran and Capitaine, it is composed of two oils, one easily soluble in water and very fragrant, while the other is sparingly soluble and has a less agreeable odour; the latter floats on the watery distillate, and is easily separated. The more fragrant oil may be extracted from the watery distillate (*orange-flower water*) by means of ether. It is reddened by *sulphuric acid*, and communicates this property to the entire essence. *Nitric acid* colours the oil brown. According to Döbereiner, oil of neroli produces a peculiar acid in contact with *platinum-black*. Oil of neroli dissolves clearly in 1—3 pts. *alcohol* of specific gravity 0·85, and with turbidity in a larger quantity. According to Boullay and Plisson, alcohol of 90 per cent. separates from oil of neroli a solid substance, **neroli-camphor**, melting at 50° C.; insoluble in water, sparingly soluble in boiling absolute alcohol; very soluble in ether; it appears to contain 83·76 per cent. C, 15·09 H, and 1·15 O; probably a hydrocarbon when pure. (Gm. xiv. 386; Gerh. iii. 639.)

The **leaves** of the orange yield a watery infusion characterised by a bitter aromatic taste.

The following table exhibits the composition of the **ash** of various parts of the orange-tree:—

Ash of Orange-tree.

	ROWNEY and BLOW.					RICHARDSON.
	Root.	Stem.	Leaves.	Fruit.	Pips.	Fruit.
er cent. . .	4·48	2·74	13·7	3·94	3·3	—
h	15·4	11·7	16·5	36·4	40·3	38·7
. . . .	4·5	3·0	1·7	11·4	0·9	7·6
. . . .	49·9	55·6	56·4	24·5	19·0	23·0
esia . . .	6·9	6·3	5·7	8·0	8·7	6·5
oxide . . .	1·0	0·6	0·5	0·5	0·8	—
uric acid (anhy- ous) . . .	5·8	4·6	4·4	3·7	5·1	2·9
c acid (anhydrous)	1·7	1·2	4.8	04	1·1	5·2
phoric acid „	13·5	17·1	3·3	11·1	23·2	14·1
ide of sodium .	1·2	0·2	6·6	3·9	6·8	trace
c phosphate . .	—	—	—	—	—	1·7

RUS **BERGAMIA.** *The Bergamot.*—The rind yields by pressure a volatile oil,
, which deposits by keeping, a solid camphor called bergaptene, having the
sition C^3H^2O. (See BERGAMOT, OIL OF, p. 580.)

RUS **BIGARADIA.** The *Bigarade* or *Bitter Orange* (*Bigaradier* of the French,
golo of the Italians).—The rind of the fruit of this plant yields by pressure a
e oil, $C^{10}H^{16}$, commonly called *Oil* or *Essence of Mandarin* (though the mandarin
is a variety of *Citrus aurantium*). After filtration, it has a pale yellowish
, but after rectification it is colourless, clear, and mobile. Specific gravity, 0·852
C., 0·8517 at 12°. Boiling point 178°. It has an agreeable odour, different
hat of lemon or orange-oil, and a not unpleasant taste, like that of orange-oil.
l rotatory power 85·5° to the right. It is insoluble in *water*, but soluble in
. of *alcohol*, also in *ether* and *glacial acetic acid*, and in all proportions in *sul-*
of carbon. It dissolves *bromine*, *iodine*, *phosphorus*, *sulphur*, *oils* both fixed
olatile, *wax*, and *resins*. With *hydrochloric acid* it forms a crystalline compound
ning $C^{10}H^{16}.2HCl$. Cold *nitric acid* colours it faintly yellow; hot nitric acid
poses it, with evolution of nitrous fumes, and the mixture, on addition of water,
its a nearly solid mass. With *alcoholic nitric acid*, it forms a crystalline mass,
bly a hydrate. It is reddened by cold *sulphuric acid*, and carbonised when
l therewith. (S. de Luca, Compt. rend. xlv. 904.—Gm. xiv. 304.)

Seville bigarade, or Seville orange, is much used for the preparation of bitter
res and of candied orange-peel. The bitter aromatic principle is a powerful tonic,
ives its flavour to the liquid called Curaçoa.

RUS **LIMETTA.** The *Lime.*—The rinds when torn and pressed, or distilled
water, yield an oil which resembles oil of lemon, and when treated with sulphuric
nd chromate of potassium, forms limettic acid, $C^{11}H^8O^6$. (Gm. *loc. cit.*)

RUS **LIMONUM.** The *Lemon.*—Regarded by many writers as a variety of
medica.

mon-juice contains free citric acid, and is used for the preparation of that acid
2), also mucus, vegetable albumin, and sugar; according to Buignet (Ann. Ch.
[3] lxi. 233), 100 pts. of it contain 1·1 grape-sugar. 0·4 cane-sugar, and 4·7 free
The nitrogenous matter causes it to putrefy easily, whence it acquires an unplea-
smell and taste; to prevent this change, it is often kept in bottles, with a layer of
its surface.

cording to Witt (Chem. Soc. Qu. J. vii. 44), lemon-juice contains from 0·2 to 0·5
ent. ash, consisting in 100 pts. of 44·3 per cent. potash, 2·1 soda, 7·6 lime, 3·3
esia, 12·5 sulphuric anhydride, 19·7 carbonic anhydride, 7·6 phosphoric anhy-
1·0 ferric phosphate, 1·2 chlorine, and 0·6 silica.

mon-pips contain in the nucleus, citrate of potassium, a fatty non-drying oil, a
-like fat, a bitter principle called *limonin*, together with other constituents.

the ash of lemon-pips, Souchay (J. pr. Chem. xxxviii. 25) found 33·2 per
potash, 3·5 soda, 12·6 lime, 8·5 magnesia, 0·2 ferric oxide, 34·1 phosphoric anhy-
, 3·2 sulphuric anhydride, 2·3 chloride of sodium, and 0·3 silica.

Oil of Lemon.—Lemon-peel contains a volatile oil, called *Oil of lemon*, *Oleum citri*, which is extracted by pressure or by distillation with water. This oil is composed for the most part of a hydrocarbon isomeric with oil of turpentine, $C^{10}H^{16}$, and having the same vapour-density (4·81—4·87). It is neutral, and has an agreeable odour. Specific gravity in the liquid state, 0·84—0·86 (Zeller). Boiling point 173° C. (Blanchet and Sell); 176·1° (Brix). It volatilises in the air at ordinary temperatures without leaving a perceptible grease-spot, provided it has not become resinous by oxidation. It deflects the plane of polarisation of light to the right.

Oil of lemon, obtained as above, is, however, a mixture of two hydrocarbons, having the same composition, but differing in optical rotatory power and in their behaviour with hydrochloric acid. These two hydrocarbons may be separated by distilling the oil in vacuo. The first portions collected at 55° C. have a density of 0·8514 at 15° C., rotatory power = + 56·4°, and when saturated with hydrochloric acid gas, yield a solid and a liquid dihydrochlorate. The following portions collected at about 80° C. have a specific gravity of 0·8506 at 15°, rotatory power = + 72·5°, and are almost wholly transformed by hydrochloric acid into a solid dihydrochlorate; they likewise contain a sensible amount of oxidised oils. (Berthelot.)

Oil of lemon dissolves sparingly in *water*, in 7·14 pts. *alcohol* of specific gravity 0·8317, in 10 pts. alcohol of specific gravity 0·85, in any quantity of absolute alcohol, and mixes readily with *oils* both fixed and volatile. It dissolves *sulphur* and *phosphorus*, also *resins* and other bodies.

Oil of lemon when exposed to *air* and *light*, absorbs oxygen, with formation of ozone, becoming at the same time darker and more viscid, and forming a small quantity of carbonic acid; according to Aschoff, the crude, but not the rectified oil, turns acid on exposure to the air, forming acetic acid and lemon-camphor. At a *red heat*, the oil is decomposed, with formation of tar and charcoal. *Chlorine* decomposes it; cotton soaked in the oil and immersed in chlorine gas becomes charred on the surface, but does not take fire. When *bromine* is covered with a layer of water, the water with oil of lemon, and the whole carefully mixed, the bromine becomes decolorised without explosion, and a brominated oil is formed, 1 pt. of rectified lemon-oil taking up 2·28 pts. and 1 pt. of the crude oil, 2·4 to 2·5 pts. of bromine (G. Williams, Chem. Gaz. 1853, p. 365). *Iodine* decomposes oil of lemon with rise of temperature. Strong *nitric acid* turns it brown and resinises it; alcoholic nitric acid converts it into a hydrate. With strong *sulphuric acid*, it assumes a yellowish brown colour, and yields terebene and colophene; similarly when distilled with *phosphoric anhydride*. Lemon-oil dropped into a large quantity of oil of vitriol is said to yield sulphoterebic acid (Gerhardt). *Potassium* eliminates hydrogen from lemon-oil, slowly at common temperatures, more quickly when heated, acquiring at the same time a brown colour; after repeated distillation over potassium, however, the oil undergoes no further alteration, and then possesses a finer odour than before. *Hydrate of potassium* separates from oil of lemon a brown substance, the oil thereby acquiring a stronger and more agreeable odour.

Oil of lemon is largely used in perfumery; it should not be dark coloured or viscid or leave a perceptible stain on paper. It is often adulterated with cheaper oils, such as oil of turpentine or oil of lavender, and sometimes with alcohol. The latter adulteration may be detected by agitation with water, the pure oil then exhibiting no perceptible diminution of volume. The pure oil is also coloured brownish by acid chromate of potassium, whereas if it contains alcohol, it turns greenish.

The admixture of cheaper oils may generally be detected by the odour. Oil of turpentine may also be detected in oil of lemon by its different behaviour to polarised light, especially when heated, the molecular constitution of oil of lemon being much less altered by heat than that of oil of turpentine. The rotatory power of the suspected oil is first to be determined at the ordinary temperature, and again after the oil has been heated to 300° C. for an hour or two. If the oil is pure, no change will be perceived, but if oil of turpentine is present, especially the French kind, which is lævo-rotatory, the dextro-rotatory power of the oil will be considerably increased by the heating.

Hydrate of Lemon-oil is a crystalline substance isomeric with hydrate of turpentine-oil, $C^{10}H^{16}.2H^2O$, obtained by mixing 1 pt. of lemon-oil with ¾ pt. alcohol, of specific gravity 0·85, and ¼ pt. ordinary nitric acid, and leaving the mixture to itself for some time. (Deville.)

Hydrochlorates of Lemon-oil.—These compounds are formed by saturating the oil with hydrochloric acid gas, also by treating the oil with the aqueous acid. The compound formed in largest quantity is the *dihydrochlorate*, $C^{10}H^{16}.2HCl$, of which there is a solid and a liquid modification, the latter being produced chiefly from the more volatile, the former from the less volatile portion of the oil. (**Berthelot**, *vid. sup.*)

Monohydrochlorate. $C^{10}H^{16}.HCl$.—This compound is produced by saturating a solution of lemon-oil in acetic acid or alcoholic sulphuric acid, with hydrochloric acid gas, and collecting the few crystals which separate, rarely, however, and only under peculiar circumstances. It appears also to be present in small quantity in the portion of lemon-oil which remains liquid after the separation of the solid dihydrochlorate. The crystals melt at 100° C., and volatilise without decomposition at higher temperatures.

Dihydrochlorate. $C^{10}H^{16}.2HCl$.—The solid modification of this compound is obtained by passing dry hydrochloric acid gas to saturation into rectified and dehydrated oil of lemon well cooled, separating the resulting crystals from the mother-liquor, pressing them repeatedly between paper, washing them with cold alcohol, recrystallising from hot alcohol, drying in the air, afterwards in vacuo or over oil of vitriol, and once more crystallising from ether (Blanchet and Sell). It forms right four-sided prisms or laminæ, heavier than water; has an aromatic odour; is insoluble in water, soluble at 14° C. in 5·88 pts. of alcohol of specific gravity 0·806; and separates from the solution, on addition of water, in crystalline laminæ. On evaporating the alcoholic solution, partial decomposition takes place. The crystals are also soluble in oils both fixed and volatile. The compound is optically inactive, melts at 43° or 44° C., and solidifies crystalline on cooling; it sublimes at 50° C. without decomposition, boils at 142° (Cahours), at 162° (Blanchet and Sell), with partial decomposition, hydrochloric acid escaping and an oil passing over, which does not solidify till cooled to 20° C. The crystals burn with difficulty when heated in the air. *Chlorine-gas* converts the fused compound, with rise of temperature, into a chlorinated compound, $C^{10}(H^{14}Cl^{2}).2HCl$, Laurent's *hydrochlorate de chlorocitrenèse.*

Dihydrochlorate of lemon-oil is decomposed by *silver* and *mercurous salts* in the cold, not by *oxide of lead*, even when heated. *Nitric acid* does not act upon it in the cold, but decomposes it when heated, with evolution of nitrous acid. *Strong sulphuric acid* decomposes it, separating hydrochloric acid. *Potassium* decomposes it, with separation of lemon-oil; if heat be applied, citrene (p. 992) is produced. The same product is obtained by repeated distillation of the compound with potash or lime, or by the action of those bases at high temperatures.

The liquid dihydrochlorate, called also *hydrochlorate of citrilene* and *hydrochlorate of citryl*, is contained in the mother-liquor of the preceding compound, and may be obtained pure by cooling the mother-liquor to −10° C. to separate the remaining quantity of the solid compound, and filtering through a mixture of chalk and animal charcoal, to remove free acid and colouring matter. It is a mobile oil, optically inactive, soluble in alcohol, and precipitated from the solution by water, with loss of hydrochloric acid. By treatment with hydrochloric acid gas, it is converted into a crystalline mass, which dissolves in alcohol, but separates therefrom, not in crystals, but in the form of a heavy oil, a small quantity remaining in solution.

Lemon-camphor or *Citroptene.*—A solid substance produced from lemon-oil by oxidation. It is formed when the oil is kept for some time in half-filled bottles, partly separating in the solid state, while the rest remains dissolved, and may be separated by rectifying the oil. It forms colourless volatile crystals, which smell like oil of lemon, have a sharp pungent taste, are neutral, insoluble in cold water, but very soluble in hot water, to which they impart a decided dichroïsm. It is soluble also in alcohol and ether, the hot saturated solutions solidifying on cooling. The compound melts at 46° C. (Mulder), above 100° (Berthelot), boils at a temperature above 100°, and distils in oil-drops, which solidify in the crystalline form; it may also be sublimed. When thrown on red-hot coals, it volatilises without taking fire. It dissolves in *sulphuric acid* with red colour and peculiar aromatic odour, and water precipitates from the solution a white resinous substance, which is insoluble in water, and does not melt at 100°. *Nitric acid* dissolves the camphor, with decomposition at common temperatures, but gives off nitrous acid when heated with it. The camphor does not absorb *hydrochloric acid.*

The composition of lemon-camphor is not known with certainty. According to Mulder, it contains 54·8 per cent. C, 9·2 H, and 36·0 O; according to Berthelot, 58·0 C, 7·5 H, and 34·5 O.

The term lemon-camphor is likewise applied to two other compounds, viz. the solid dihydrochlorate of lemon-oil, and the hydrate formed by the action of alcoholic nitric acid on the same oil.

Citrus Lumia. The *Sweet Lemon.*—This plant, which grows abundantly in Calabria and Sicily, yields a fruit very much like the common lemon. The rind yields by pressure a volatile oil, the greater part of which distils between 180° and 190° C. yielding a colourless limpid liquid.

The portion boiling at 180° is isomeric with oil of turpentine, &c., and has a density of 0·853 at 18°. It possesses a dextro-rotatory power = 34° for the transition-tint.

It is slightly soluble in *alcohol*, very soluble in *ether* and in *sulphide of carbon*. It is resinised by strong *nitric acid*, and, like oil of lemon, yields a crystalline hydrate with alcoholic nitric acid. With *hydrochloric acid*, it forms a liquid and a crystalline compound; the latter, which has a peculiar odour and melts a low temperature, is a *dihydrochlorate*, $C^{10}H^{16}.2HCl$. (S. de Luca, Compt. rend. li. 258.)

CITRUS MEDICA. The *Citron*. (*Citradier* of the French, *Cedro* or *Cedrato* of the Italians.)—The fruit of this species is usually large, warted and furrowed, with an extremely thick spongy rind and a subacid pulp. It is chiefly valued for the fragrance of the rind, from which a delicate sweetmeat is prepared. Two volatile oils used in perfumery are extracted from it, viz. *oil of citron* and *oil of cedra*. Both are highly fragrant, almost colourless, and lighter than water; they are distinguished by their odour, that of oil of cedra partaking of the character of oil of bergamot. The two oils are often confounded by pharmaceutical writers. They appear to be obtained by distillation, as they are free from mucilage. Both of them are *hydrocarbons* isomeric with oil of turpentine. (Pereira, *Materia Medica*, 3rd ed. 1853, ii. 2032.)

CITRYL. This name is applied to the triatomic radicle, $C^6H^5O^4$, of citric acid, &c.; also by Blanchet and Sell to that portion of lemon-oil which forms a liquid compound with hydrochloric acid (p. 1002).

Chloride of citryl $(C^6H^5O^4)'''Cl^3$, appears to be formed, together with oxychlorocitric acid and chloride of aconityl, when citric acid is heated with pentachloride of phosphorus (p. 997), inasmuch as the mother-liquor which remains after the oxychlorocitric acid has crystallised out, yields, on addition of water, both citric and aconitic acids. (Pebal.)

The following is a list of the compounds of citryl described in preceding articles. $[C^6H^5O^4 = Ci]$.

Chloride of Citryl . . .	$Ci'''Cl^3$	Citrate, diglyceric .	$\left.\begin{matrix}Ci'''\\2(C^3H^5)'''\\H^3\end{matrix}\right\}O^9$
Citric acid	$\left.\begin{matrix}Ci'''\\H^3\end{matrix}\right\}O^3$	Citromannitan . . .	$\left.\begin{matrix}Ci'''\\(C^6H^8)^{iv}\\H^3\end{matrix}\right\}O^9$
Citrates, monometallic . .	$\left.\begin{matrix}Ci'''\\H^2M\end{matrix}\right\}O^3$	Dicitromannitan . . .	$\left.\begin{matrix}Ci'''\\Ci'''\\(C^6H^8)^{iv}\end{matrix}\right\}O^5$
Citrates, dimetallic . . .	$\left.\begin{matrix}Ci'''\\HM^2\end{matrix}\right\}O^3$	Citramide	$\left.\begin{matrix}Ci'''\\H^3\\H^3\end{matrix}\right\}N^3$
Citrates, trimetallic . .	$\left.\begin{matrix}Ci'''\\M^3\end{matrix}\right\}O^3$	Phenylcitramide . .	$\left.\begin{matrix}Ci'''\\(C^6H^5)^3\\H^3\end{matrix}\right\}N^3$
Citrate, monomethylic . .	$\left.\begin{matrix}Ci'''\\CH^3\\H^2\end{matrix}\right\}O^3$	Phenylcitrimide . .	$\left.\begin{matrix}Ci'''\\(C^6H^5)^2\\H\end{matrix}\right\}N^2$
Citrate, dimethylic . .	$\left.\begin{matrix}Ci'''\\(CH^3)^2\\H\end{matrix}\right\}O^3$	Phenylcitramic acid . .	$\left.\begin{matrix}C^6H^5\\Ci'''\\H\end{matrix}\right\}\begin{matrix}N\\O\end{matrix}$
Citrate, trimethylic .	$\left.\begin{matrix}Ci'''\\(CH^3)^3\end{matrix}\right\}O^3$	Diphenylcitramic acid . .	$\left.\begin{matrix}(C^6H^5)^2\\Ci'''\\H^3\end{matrix}\right\}\begin{matrix}N^2\\O\end{matrix}$
Citrate, triethylic . .	$\left.\begin{matrix}Ci'''\\(C^2H^5)^3\end{matrix}\right\}O^3$		
Citrate, monoglyceric .	$\left.\begin{matrix}Ci'''\\(C^3H^5)'''\end{matrix}\right\}O^3$		

CIVET. An odoriferous substance obtained from animals of the genus *Viverra* (Cuv.), viz. the *Viverra civetta* of North Africa, *V. zibetha*, found on the continent of Asia, from Arabia to Malabar, and *V. Rasse* of Java. It is contained in a pouch situated between the anus and organs of generation, and is voided by the animals against shrubs or stones. A better quality is, however, obtained by keeping the animals in confinement, and squeezing the pouch at certain intervals.

Good civet is of a clear yellowish or brownish colour, not fluid, or hard, but of about the consistence of butter or honey, and uniform throughout, of a very strong smell, resembling musk or ambergris; quite offensive when undiluted, but agreeable when only a small portion of civet is mixed with a large quantity of other substances.

unites with oils, but not with alcohol.

ron-Charlard states, that in an unexceptionably good civet, semi-fluid, unctuous llow, he found free ammonia, stearin, oleïn, mucus, resin, volatile oil, yellow ng substance, and salts. No benzoic acid could be detected in it. (J. Pharm. . 537.)

ARIFICATION. Clarification is the process of freeing a liquid from heteous matter or feculencies; the term is, however, seldom applied to the mere ical process of straining, for which see Filtration.— Albumin, gelatin, acids, salts, lime, blood, and alcohol, serve in many cases to clarify fluids, which be freed from their impurities by simple percolation. Albumin or gelatin, ed in a small portion of water, is commonly used for fining vinous liquors, as cates the feculent matter, and gradually subsides with it to the bottom. Al- in the form of white of egg or serum of blood is particularly used for fluids with it will combine when cold, as syrups; as it is coagulated by the heat, and then a scum with the dregs.—Heat alone clarifies some fluids, as the juices of in which, however, the albumin they contain is probably the agent.—A couple dfuls of marl, thrown into the press, will clarify cider, or water-cider.

y finely divided precipitates, which remain for a long time suspended in pure may often be made to settle down, by adding a soluble salt, such as salniac, to the water. The same addition greatly facilitates the filtering and wash- precipitates, which otherwise stop up the pores of the filter.

ASSIFICATION. The object of a classification of chemical substances is rangement of them in such a way that the position in the system of each sub- may express its own chemical nature and the relation in which it stands to substances. Hence it is easy to see that a system of classification, which d be perfect, relatively to any given stage in the development of the science, be an epitome of the whole mass of chemical knowledge existing at the time. erto but slight advances have been made towards establishing a theory of the s or essential nature of chemical action; our so-called chemical theories are, e most part, attempts to express the mutual relations of a greater or lesser num- f chemical substances; in reality, therefore, they are more or less comprehen- schemes of classification. A general system of chemical classification ought to ace the fundamental principles of all such partial systems, so as to show the nature and relative value of each: it ought, in fact, to be a general expression ese theories in much the same sense that they are general expressions of ical facts. A discussion of the bases upon which a comprehensive classification be founded becomes therefore a discussion of chemical theories in general; and is article we shall endeavour to set forth clearly those general results of chemical rch, by reference to which the true value of all chemical theories must, in the nt state of the science, be tested, and which must for the present, be taken as the lation for any attempt at chemical classification, rather than to construct a detailed ne of classification in which each individual substance should find its place.

collection of complex objects can always be classified in several different ways, ding as this or that quality is regarded as the most important. In the case of ical substances, two causes are always at work to bring about changes of the of view from which they are regarded with reference to their classification. In rst place, the number of objects to be classified is continually increasing through iscovery of new substances; and, in the second place, the finding out of new ties in the bodies already known, tends continually to modify their apparent ons to each other. Hence it is not surprising that, instead of our being able to in the history of chemistry, the gradual extension of one fundamental scheme of fication, we should find that the principles upon which it has been attempted to fy chemical substances have been gradually, but from time to time almost letely changed as the science has advanced. It is not necessary to consider here these changes have been; we have only referred to their occurrence, in order aw attention to the fact, that the most perfect classification which it is possible now to give, can of necessity be nothing more than a representation of the results emical labour, as they appear viewed from the point which the science has now ed, and that it must hereafter be absorbed in some more general system, if it be ntirely set aside.

l chemical substances belong to one of two classes: namely, elements or simple es, and compound bodies. The chemical definition of an element is—a which cannot be decomposed or shown to contain matter of more than one ; compound bodies, on the other hand, are such as are made up of, or can be de- osed into, two or more distinct kinds of matter. For instance, water can be shown to contain two kinds of matter, called respectively oxygen and hydrogen; sugar can similarly be proved to be made up of oxygen, hydrogen and carbon; water and sugar are therefore both of them compound bodies; but neither oxygen, hydrogen, nor carbon can, by any analytical or *breaking-up* process, be made to yield anything else than oxygen, hydrogen, or carbon, respectively; these three bodies are therefore in a chemical sense, elements. It will be seen that the chemical idea of an elementary body does not by any means imply the absolute simplicity of the so-called elements; it may be that these bodies are compounds which, as yet, have resisted all attempts to decompose them, but which are capable of being decomposed by processes hitherto unknown. Nevertheless, if it should at some future time be shown that all our present elements are in reality compound bodies, the definition of elements as bodies which cannot be chemically decomposed would still hold good, though it would then be applicable to a new set of substances.

In the further classification of elementary and compound bodies, it is impossible to separate the consideration of one of these classes from that of the other; for the chemical nature of an elementary body can only be known by the study of the combinations which it forms; and the properties of every compound body are determined by those of the elements of which it is composed.

There are especially two points to be considered in reference to the relation in which the various elements stand to the compounds which they form: first, the atomic proportion in which they combine together; second, the chemical nature or function of the bodies into whose composition they enter. Considering them first in the former relation, we find that there are a certain number which are distinguished from all the rest by the simplicity of the proportion in which they unite with each other. To this class of elements belong hydrogen (H = 1), chlorine (Cl = 35·5), bromine (Br = 80), iodine (I = 127), potassium (K = 39), sodium (Na = 23), lithium (Li = 7), rubidium (Rb = 85·4), cæsium (Cs = 133), silver (Ag = 108).* They combine together usually in the proportion of one atom to one atom (see ATOMIC WEIGHTS), and but few compounds are known which contain more than two of these elements, unless an element of some other class be also present. Trichloride of iodine, ICl^3 †, and the supposed chloride of bromine, $BrCl^5$, are perhaps the only exceptions to the former of these rules, and the substances which form an exception to the second are all crystallised salts formed by the molecular union of normal binary compounds, such as NaCl and AgCl. These bodies cannot be proved to exist, except in the crystallised state, and the chemical properties of their two constituents are not modified to the extent which usually accompanies true chemical combination; hence it is probable that they are not true chemical individuals, but physical aggregates of entire molecules, analogous to salts containing water of crystallisation. Another property of the elements of this class, closely allied to the first that was mentioned, is that the proportion by volume in which those of them which can be measured in the gaseous state unite, is 1 : 1.

For reasons that will be further dwelt upon in the sequel, the elements of this class are termed *monatomic* elements; the remainder are termed *polyatomic* elements and are divisible into:

1. *Diatomic Elements.*—These are: oxygen (O = 16), sulphur (S = 32), selenium (Se = 80), tellurium (Te = 128), magnesium (Mg = 24), zinc (Zn = 65), cadmium, (Cd = 112), mercury (Hg = 200), calcium (Ca = 40), strontium (Sr = 88), barium (Ba = 137), platinum (Pt = 98·5), and perhaps others. The elements of this class combine either two or more together and in very various proportions, *e. g.* ZnO, ZnS, SO^2, SO^3, CaS^5, Ba^2SO, $BaSO^2$, $BaSO^3$, $BaSO^4$, BaS^2O^3, BaS^2O^6, BaS^4O^6. They combine with the monatomic elements in the proportion of one atom or volume to two, forming compounds of which one molecule occupies twice the volume of the diatomic atom it contains, and the same volume as the two monatomic atoms: *e. g.* H^2O, Cl^2O, ClHO, KHS, &c. When more than one atom of a diatomic element enters into combination with one or more monatomic elements, the ratio of combination is sometimes much more complex: *e. g.* H^2O^2, Cl^2S^2, Cl^2SO, Cl^2SO^2, $KHSO^3$, $KHSO^4$, &c.‡

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* Fluorine is usually regarded as also belonging to this class, being associated with chlorine, bromine, and iodine; its known analogies to these bodies are not, however, either close or numerous, while its great tendency to unite at the same time with two different metals, or with hydrogen and a metal, seems to indicate that it ought rather to be placed in the next class of elements (F = 38, hydrofluoric acid = FH^2).

† This is not the only case in which iodine forms a compound of greater complexity than other members of the same class: for instance, iodic acid forms anhydro-salts, which are without analogues among the compounds of the other monatomic elements.

‡ Several elements are here enumerated as diatomic which were till lately regarded as monatomic. The question whether magnesium, zinc, cadmium, and mercury, and calcium, strontium, and barium, ought to be considered diatomic instead of monatomic, resolves itself into the question whether the accepted atomic weights of these elements ought to be doubled. We cannot discuss this question fully here, and must confine ourselves to the statement of certain facts whose bearing on the point will be

2. *Triatomic Elements.*—Nitrogen ($N = 14$), phosphorus ($P = 31$), arsenic ($As = 75$), antimony ($Sb = 121$), bismuth ($Bi = 208$); boron ($B = 11$); gold ($Au = 197$); probably molybdenum ($Mo = 48$), vanadium ($Vd = 68{\cdot}5$), tungsten ($W = 92$); and perhaps others.

These elements do not form many combinations among themselves not containing any element belonging to another class. They combine with the monatomic elements in the proportion of 1 at. to 3, to form such bodies as NH^3, PH^3, AsH^3, $SbAg^3$, $BiCl^3$, BCl^3, $AuCl^3$, &c.; 1 at. of some of them can also combine with 5 monatomic atoms, many bodies of the following form being known: NH^4Cl, PH^4I, PCl^5, &c.; but none of these compounds appear to be capable of volatilising without decomposing, so as to regenerate a compound of the class first mentioned, as shown in the following examples:—

$$NH^4Cl = NH^3 + HCl$$
$$PCl^5 = PCl^3 + ClCl.$$

With the diatomic elements and with the diatomic and monatomic elements together, they combine in very various proportions, but always so that the sum of the triatomic atoms, or of the triatomic and monatomic atoms together, when the latter are present, contained in a molecule of the products formed, is an even number.

3. *Tetratomic Elements.*—Carbon ($C = 12$), silicon ($Si = 28{\cdot}5$), titanium ($Ti = 48{\cdot}5$), tin ($Sn = 118$), tantalum ($Ta = 138$); probably lead ($Pb = 207$), and perhaps other elements.

These elements can combine with the monatomic elements in the proportion of 1 at. to 2 (*e.g.* $SiCl^2$, $SnCl^2$), and with the diatomic elements in the proportion of 1 at. to 1 (*e.g.* CO, SiO, SnO); but the compounds so produced readily combine with 2 monatomic atoms, or with 1 diatomic atom, to form such bodies as the following: $SiCl^4$, $SnCl^4$, $COCl^2$, CO^2, SiO^2, &c., which appear to represent the normal compounds of the tetratomic elements. They also form very many compounds with the triatomic elements, or with these and the monatomic or diatomic elements together. The following are examples of the simplest combinations so produced:

$$C^2N^2,\ CNH,\ CNHO.$$

4. *Hexatomic Elements.*—The following elements are perhaps hexatomic: iron ($Fe = 112$), aluminium ($Al = 54$), and other similar bodies.

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understood if the reader has studied the article ATOMIC WEIGHTS. See also METALS, ATOMIC WEIGHTS and CLASSIFICATION OF, vol. iii. pp. 958-963; and ATOMICITY in the SUPPLEMENT.

a. Magnesium, Zinc, Cadmium, Mercury.—Of these four elements it may be said, that the evidence in favour of doubling the atomic weights of zinc and mercury is conclusive, while magnesium and cadmium are so obviously members of the same natural family, that it is not possible to double the atomic weights of the former two metals without doubling theirs also. The most important reason for doubling the atomic weights of zinc and mercury are the following:—When these metals act upon the iodides of the alcohol-radicles, 65 pts. zinc or 200 pts. mercury combine directly with the quantities represented by the formulæ CH^3I, C^2H^5I, $C^5H^{11}I$, C^3H^5I, in each case forming a single product, such as $Zn''C^2H^5I$, $Hg''C^2H^5I$, $Hg''C^3H^5I$, &c., as though 65 pts. zinc and 200 pts. mercury, represented indivisible quantities, or atoms, of those metals, whereas if these weights represented two atoms, we should expect that the action of 65 pts. zinc or of 200 pts. mercury on C^2H^5I would give rise to two distinct products, ethylide and iodide of zinc or of mercury. The combination which actually takes place is analogous to the combination of (the diatomic element) oxygen with cyanide of potassium:

$$KCy + O = KCyO;$$

if zinc and mercury were monatomic, their action on the hydriodic ethers would probably be analogous to that of (the monatomic element) chlorine on cyanide of potassium:

$$KCy + Cl^2 = KCl + CyCl.$$

Again, the reactions represented by the following equations (and the similar reactions which take place with mercury-methyl) all tend to show that a molecule of mercury-ethyl (or mercury-methyl) contains 2 at. ethyl (or methyl):

$$\overset{''}{Hg}(C^2H^5)(C^2H^5) + BrBr = \overset{''}{Hg}(C^2H^5)Br + C^2H^5.Br \text{ (Buckton).}$$

$$\overset{''}{Hg}(C^2H^5)(C^2H^5) + ClH = \overset{''}{Hg}(C^2H^5)Cl + C^2H^5.H \text{ (Buckton).}$$

$$\overset{''}{Hg}(C^2H^5)(C^2H^5) + \overset{''}{Hg}ClCl = \overset{''}{Hg}(C^2H^5)Cl + \overset{''}{Hg}Cl(C^2H^5) \text{ (Buckton),}$$

and it is difficult to understand what can cause the two atoms of alcohol-radicle to remain combined, if it be not that the quantity of mercury with which they are united is one indivisible atom.

To these chemical arguments may be added that drawn from the determinations which have been made of the vapour-densities of zinc and mercury compounds. All the determinations hitherto made agree with the supposition that the atomic weights of these metals are 65 and 200 respectively, and not 32·5 and 100, as generally admitted; the specific heats of these metals point also to the same conclusion.

We may add, finally, that the readiness with which all the four metals under consideration form basic salts is a further indication of their diatomic character.

β. Calcium, Strontium, Barium.—The decomposition of the hydrates of these metals by heat alone, taken in connection with their general close resemblance to the alkalis, may be regarded as evidence of their being hydrates of diatomic radicles bearing the same relation to the hydrates of potassium, sodium, &c., that the bibasic acids (most of which are similarly decomposed by heat) bear to the monobasic acids. Moreover, the non-existence of acid carbonates, sulphates, oxalates, &c., of any of them seems to show that the quantities of metal (twice the quantities usually admitted as representing their atomic weights) contained in their neutral salts with bibasic acids are indivisible. Notwithstanding, however, these and some other indications of a diatomic character, the atomicity of calcium, strontium, and barium must be considered as still more or less open to question.

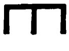
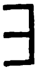
The existence of this class is not as yet certainly proved; there is, however, reason to believe that iron, aluminium, and perhaps some of the metals most closely allied to them, are hexatomic, and that their simplest compounds with the monatomic elements contain 6 monatomic atoms (*e.g.* sesquichloride of iron, $FeCl^6$; chloride of aluminium, $AlCl^6$).

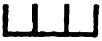
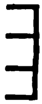
Notwithstanding the exceptions which we have pointed out, the difference in the modes of combination of various elements, which have been indicated as serving for their division into distinct classes, are in the main so marked and so constant as almost to make the conclusion unavoidable that they result from differences in the combining capacity of the elementary atoms themselves; that in fact the *atomic combining capacity* or *atomicity* of the various elements is a definite and fixed property comparable to their atomic weight. And, if it be accordingly admitted that an atom of oxygen, or of any other element of the same class, can combine with *twice* as great a weight of any given element as an atom of hydrogen, or of any other element of its class,—that an atom of any element of the nitrogen-class can combine with *three* times as much, and an atom of any element of the carbon-class with *four* times as much (that is, if the terms monatomic, diatomic, triatomic, and tetratomic, applied to the various classes into which the elementary bodies have been divided, be admitted to correspond to actual differences in the combining powers of the *atoms* of the elements),—then it is possible to explain, at least to a very great extent, the general differences of composition which the compounds of these elements show when compared together.

Upon the classification of the elementary bodies which we have here adopted, we have now to found a classification of their compounds. [In this part of the subject it will often be convenient to use the following general signs for denoting elements of the various classes:

For monatomic elements, a vertical or horizontal stroke: | or —

For diatomic elements, two such strokes connected at one end by a straight line or

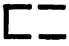
For triatomic elements, three strokes connected:  or 

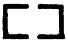
For tetratomic elements, four strokes connected:  or 

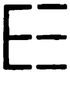
The number of strokes in the sign of each class of elements thus represents their atomicity.]

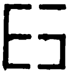
The simplest normal combinations which one monatomic, diatomic, triatomic, or tetratomic atom respectively can form, are the following:

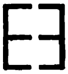
1. Monatomic atom with monatomic, — —; example: $\overset{\prime}{H}\overset{\prime}{Cl}$.

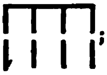
2. *a.* Diatomic atom with 2 monatomic, ; examples: $\overset{\prime\prime}{O}\overset{\prime}{H}{}^2$, $\overset{\prime\prime}{O}\overset{\prime}{H}\overset{\prime}{K}$.

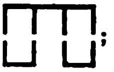
b. Diatomic atom with diatomic, ; example: $\overset{\prime\prime}{O}\overset{\prime\prime}{Hg}$.

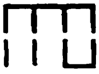
3. *a.* Triatomic atom with 3 monatomic, ; example: $\overset{\prime\prime\prime}{N}\overset{\prime}{H}{}^3$, $\overset{\prime\prime\prime}{N}\overset{\prime}{H}{}^2\overset{\prime}{K}$.

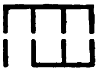
b. Triatomic atom with 1 monatomic and 1 diatomic, ; examples: $\overset{\prime\prime\prime}{N}\overset{\prime}{Cl}\overset{\prime\prime}{O}$ $\overset{\prime\prime\prime}{Sb}\overset{\prime}{Cl}\overset{\prime\prime}{O}$.

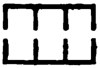
c. Triatomic atom with triatomic, ; example: $\overset{\prime\prime\prime}{N}\overset{\prime\prime\prime}{B}$.

a. Tetratomic atom with 4 monatomic, ; examples: $\overset{\text{iv}}{C}\overset{\prime}{H}{}^4$, $\overset{\text{iv}}{C}HCl^3$, $\overset{\text{iv}}{C}\overset{\prime}{H}{}^2\overset{\prime}{I}{}^2$.

b. Tetratomic atom with 2 diatomic, ; examples: $\overset{\text{iv}}{C}\overset{\prime\prime}{S}{}^2$, $\overset{\text{iv}}{Si}\overset{\prime\prime}{O}{}^2$.

c. Tetratomic atom with 2 monatomic and 1 diatomic, ; examples: $\overset{\text{iv}}{C}\overset{\prime}{Cl}{}^2\overset{\prime\prime}{O}$, $\overset{\text{iv}}{Pb}\overset{\prime}{Cl}{}^2\overset{\prime\prime}{O}$.

d. Tetratomic atom with 1 monatomic and 1 triatomic, ; example: $\overset{iv}{C}H\overset{iii}{N}$.

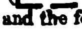
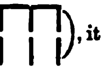
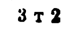
e. Tetratomic atom with tetratomic, 

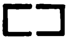
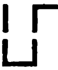
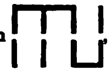
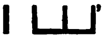
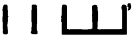
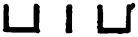
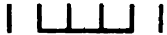
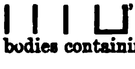
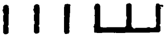
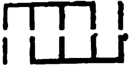
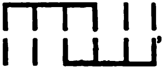
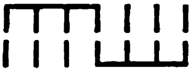
It will be seen that this classification of compounds of the simplest order is equivalent to Gerhardt's classification according to types. Compounds of the form 1 are those referred by him to the type HCl or HH; those of the form 2*a*, are those referred to the type H^2O; those of the form 3*a*, are those referred to the type H^3N; while bodies of the form 4*a* may be referred to the type H^4C, subsequently introduced (by Odling, Kekulé, and others) for the purpose of further extending Gerhardt's system. The sub-forms 2*b*, 3*b*, 3*c*, 4*b*, 4*c*, 4*d*, 4*e*, may be regarded as deriving from the primary forms, if we take account of the multequivalency of the polyatomic elements (see EQUIVALENTS), and consider, for instance, chloroxide of carbon (4*c*) as representing a body of the form 4*a*, in which the diequivalent atom O takes the place of 2 monatomic atoms, and hydrocyanic acid (4*d*) as a body of the same form in which the triequivalent atom N takes the place of 3 monatomic atoms. In this way all bodies such as those above mentioned, may be referred to the four types HCl, H^2O, H^3N, H^4C; so far, then, the empirical classification of Gerhardt, and that which we have here deduced from the theoretical basis of the definite atomicity of the elements, are identical.

In order to extend his classification to compounds of a higher degree of complexity, Gerhardt was obliged to assume the existence of an indefinite number of compound radicles: we have now to consider the constitution of such compounds, and shall thus see that the idea of the atomicity of the elements includes, not only the idea of types, but also the idea of compound radicles,—ideas which recent chemistry has shown to be correlative, neither of them having any significance except in relation to the other.

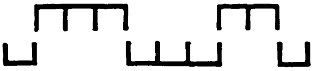
Comparing now more complex compounds with each other and with the very simple compounds of which we have been speaking, we find that, whereas there is no rule as to the number of diatomic or tetratomic atoms which one compound may contain more or less than are contained in another, the difference between the number of monatomic or of triatomic atoms, or of monatomic and triatomic atoms together when both are present, contained in two well defined and well analysed bodies, is always an even number. But since the compounds constituted according to any of the forms above enumerated always contain an even number of monatomic, or of triatomic, or of monatomic and triatomic atoms together, this amounts to saying that *the sum of such atoms contained in any well-defined and well-analysed body is always an even number*. This proposition embodies one of the earliest observed regularities in the atomic composition of compound bodies (*vid.* Laurent, Ann. Ch. Phys. [3] xviii. 266), often spoken of as *the law of the even number of atoms*; it is in strict accordance with the view which regards the combination of the elements as consisting in the mutual saturation of their atomic combining capacities, and might indeed be deduced from it: for since each unit of combining capacity requires another for its saturation, the number of atoms in every normal compound (or compound in which the atomicity of each element is saturated) must be such, that the number representing the sum of their combining capacities is even; and this can only be the case when it contains an even number of those atoms (monatomic and triatomic atoms) whose atomicity is represented by an odd number.

The highest number of monatomic atoms that any compound can contain appears to be regulated by the number and nature of the polyatomic atoms which it contains. If a compound contain n polyatomic atoms whose atomicities are respectively A, A', A'', &c., the highest number of monatomic atoms that it can contain is $A + A' + A'' + \ldots\ldots - 2(n-1)$; but it may contain any lower number differing from this by a multiple of 2.

We may illustrate this rule by applying it to the simplest normal compounds of atoms of each degree of atomicity. In the case of compounds of the form 1 (— —), $A+A'$, &c., $= 0$, n also $= 0$, therefore the formula becomes $-2(-1)=2$; in the case of compounds of the form 2*a*, ( A', A'', &c., disappear, and $n=1$, so that the term $2(n-1)$ also disappears, and the formula is reduced to $A=2$, in like manner in the case of compounds of the form 3*a*, , the formula becomes $A=3$; and in the case of those of the form 4*a*, , it becomes $A = 4$. All compounds belonging to any of these four classes, contain therefore the maximum number of monatomic atoms. We have previously alluded to some substances in which this maximum appears to be exceeded: namely, first, compounds containing *four* or *six* monatomic atoms, such as $NaAgCl^2$ (?) and K^2AgI^3; secondly, compounds containing *five* monatomic atoms to one triatomic atom, such as NH^4Cl, PCl^5, &c. There is, however, as already pointed out, reason to believe that all such bodies as these are not strictly speaking chemical individuals, but that they are combinations of entire molecules, as such, held together by a force analogous to that which causes certain salts to combine with water of crystallisation. This view may be easily admitted with reference to the first set of exceptional substances, because they cannot be proved to exist, except in the crystalline state: being generally decomposed by solution in a moderate quantity of water, they are often not very constant in the proportions of their ingredients, and the two salts, of which they may be regarded as made up, retain their usual properties without essential alteration. In the case of some of the second class of exceptional bodies, the difficulties in the way of admitting this explanation are greater. These bodies are so numerous, and some of them form so readily and are under certain ordinary conditions so stable, that some chemists have been led to regard nitrogen, phosphorus, arsenic and antimony as pentatomic instead of triatomic. The chief reason for not adopting this conclusion is that, in all such compounds, two of the monatomic atoms appear to be more loosely combined than the other three, so that even the most stable compounds of this kind, namely the ammonia-salts, are always decomposed to a greater or less extent by the evaporation of their solutions, and not one body of this class appears to be volatile without decomposition (into a compound of the form 1, and a compound of the form 3*a*). But whatever be the real nature of these compounds and of the force which causes their formation, it is certain that they differ in important respects from substances whose composition accords with the atomicity of their components, and that their properties are to a great extent explicable if we regard them as combinations of entire molecules produced independently of the combining capacities of their constituent atoms. (To prevent repetition, we may state here that the same view is applicable to all other compounds of ammonia and similar bodies with acids.)

But to return and consider how far the composition of other bodies agrees with the formula which we have said gives the highest possible number of monatomic atoms that they can contain. It results from the formula that bodies containing two diatomic atoms can contain also two monatomic atoms. Accordingly there exist not only compounds of the form  (referred to above by the number 2*b*), but also compounds of the form , for example, $SOCl^2$, O^2H^2. For bodies containing one triatomic and one diatomic atom, the formula gives 3 as the highest number of monatomic atoms that they can contain; accordingly, in addition to compounds of the form 3*b*, there exist compounds of the form , for example, $NOCl^3$, $POCl^3$. Bodies like those of the form 3*c*, containing two triatomic atoms may, according to the formula, contain at most four monatomic atoms: agreeably with this result, compounds are known of the form , for example, $NPCl^2$, and of the form , for example, P^2I^4. Bodies containing one tetratomic and two diatomic atoms (4*b*) may by the same rule contain *four* monatomic atoms: hence we may have bodies of the form  example, CO^2H^2 (formic acid), and bodies of the form ; methylic glycol, CO^2H^4, if known, would be an example of this class. Similarly, bodies containing one tetratomic and one diatomic atom (4*c*) may contain four monatomic atoms, forming compounds of the form , for example, COH^4 (methylic alcohol), CSH^4 (methylic mercaptan); bodies containing one tetratomic and one triatomic atom (4*d*) may contain five monatomic atoms, forming compounds of the form  for example, CNH^5 (methylamine); and bodies containing two tetratomic atoms (&c.), may contain two, four, or six monatomic atoms giving compounds of the form  example, C^2H^2 (acetylene); , example, C^2H^4 (ethylene); or  example, C^2H^6 (hydride of ethyl)

The question now arises, how far is this law of the combination of the different elements in accordance with the idea of their having each a definite and constant atomicity? A little consideration will show that it is a necessary consequence of that supposition. The total combining capacity of any number of atoms is evidently the sum of their several combining capacities, and if these latter be denoted by A, A′, A″, &c., will be expressed by A + A′ + A″ + ...; but if the atoms be combined together, their total combining capacity will not be so great as in the free state, it will have been more or less saturated by the combination which has taken place among them. The atomicity of as many of them as are monatomic, will have been entirely saturated by the combination, but the atomicity of such as are polyatomic may be only partially saturated; and it will be saturated to the smallest possible extent if, of all but two of them, two units of combining capacity be saturated each by one unit of a different atom, and if one unit of each of the remaining two atoms be saturated. This mode of combination is shown by the following diagram, representing 2 tetratomic atoms, 1 triatomic atom, and 2 diatomic atoms combined in the way described: —



Since the free atomicity (if we may use the expression) of all but two atoms is thus diminished by two units, and the free atomicity of each of the remaining two atoms is diminished by one unit, the total remaining free atomicity of the group is equal to the total atomicity of the uncombined atoms (or A + A′ + A″ + ...), diminished by (2(n − 2) + 2),

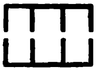
$$\text{that is:}\quad A + A' + A'' + \ldots . - 2(n-2) - 2 = A + A' + A'' + \ldots . - 2(n-1),$$

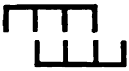
which is the precise expression, some of whose consequences we have above discussed.

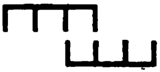
It is evident that no combination can take place without the saturation of at least two units of atomicity, one belonging to each of the combining atoms. Hence, when a monatomic atom combines with any other atom, or group of atoms, the atomicity of the product must be one less than that of such atom or group of atoms: for the monatomic atom brings to the compound that is formed only one unit of atomicity, whereas two units are saturated by the combination. Therefore, as we have seen, the number of monatomic atoms with which any atom or group of atoms can combine, is always limited. For similar reasons the total atomicity of any atom or group is the same as that of its compound with a diatomic atom. From this follow the several consequences: first, there is *a priori* no assignable limit to the number of diatomic atoms with which a given atom or group may combine; secondly, compounds which do not contain atoms whose atomicity is represented by a higher number than 2, never contain more than two monatomic atoms; *e.g.* water, H^2O, and sulphydric acid, H^2S, each contain two monatomic and one diatomic atom, while pentathionic acid, $H^2S^5O^6$, contains eleven diatomic, but still only two monatomic atoms; thirdly, compounds containing the maximum number of monatomic atoms do not become able to combine with a greater number through union with any number of diatomic atoms; *e.g.* hydride of hexylene, C^6H^{14}, contains the maximum of monatomic atoms, but mannite, $C^6H^{14}O^6$, differing from it by containing O^6 additional, is not capable of further combination with monatomic atoms. When a triatomic atom enters into combination, it brings to the compound three units of atomicity, and two units are saturated by the combination, so that the entire atomicity of the product exceeds that of the original substance by one. Hence, when a triatomic element, as nitrogen, combines with a group already containing the maximum of monatomic atoms, the group becomes able to take up an additional monatomic atom; accordingly, we have many compounds which differ by NH, or a multiple of it, *e.g.*, C^2H^6 (hydride of ethyl), C^2H^7N (ethylamine), $C^2H^8N^2$ (ethylene-diamine); C^2H^4O (aldehyde), C^2H^5NO (acetamide); $C^2H^4O^2$ (acetic acid), $C^2H^5NO^2$ (glycocine). When a tetratomic atom is added to a group, the total atomicity of the product in like manner exceeds that of the original substance by 2. Hence the possibility of the many series of compounds of which the terms differ by CH^2 or by a multiple thereof.

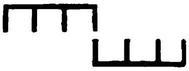
It will be understood that the foregoing remarks touching the combining capacity of various atomic groupings, and the way in which it is affected by the addition of atoms of various kinds, have reference only to the *highest number* of monatomic atoms that is ever found in combination with a given number of polyatomic atoms; and that it is by no means intended to imply that all compounds contain, or even show any great tendency to combine with, the whole number of monatomic atoms which the rules above given indicate as the maximum in each case. Several compounds not containing the maximum of monatomic atoms have already been incidentally referred to; but it is necessary that the constitution of such compounds should be somewhat more specially discussed in relation to the theory of the definite combining capacity of the elementary atoms.

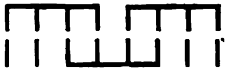
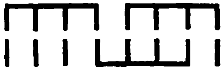
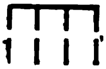
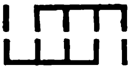
According to this theory, there are four different ways in which it is possible for two tetratomic atoms, for instance, two atoms of carbon, to combine. Two such atoms may mutually saturate, either the whole, three fourths, one half, or one fourth of each other's combining capacity, as expressed by the following diagrams: —


Each atom
completely saturated.


Each atom
¾ saturated.


Each atom
½ saturated.


Each atom
¼ saturated.

The first diagram probably represents some variety of free carbon; the second, third, and fourth, the manner in which the two carbon-atoms are combined in acetylene, C^2H^2, ethylene, C^2H^4, and hydride of ethyl, C^2H^6, respectively. In the last of these bodies, one unit only of the combining capacity of each carbon-atom is saturated by the other, leaving three units of affinity belonging to each free for combination with hydrogen; and it is plain that two atoms of carbon can only combine with a larger number of hydrogen, or other monatomic atoms, than are contained in this compound, when they are entirely uncombined with each other. In ethylene and acetylene, on the other hand, the two atoms of carbon are so combined that, if we may so speak, they can combine with an additional number of monatomic atoms by loosening, without entirely giving up, their hold upon each other. And in all compounds in which the proportion of monatomic to polyatomic atoms is below the maximum indicated by the formula given higher up, we must, unless we suppose the atomicity of the elements to be variable (in which case the word atomicity ceases to have any special meaning), suppose that a greater or lesser number of the polyatomic atoms are combined in a similar way. But, in the great majority of such cases, the composition alone of a compound does not enable us to decide as to how many of its polyatomic atoms are in this kind of more intimate union with each other. For example, allylene, C^3H^4, homologous with acetylene, might, so far as its mere composition is concerned, be constituted either thus , or thus ; its properties, however, would be somewhat different in the two cases. It would not be possible to combine a compound constituted in the first manner with two atoms of hydrogen, without transforming it into propylene, C^3H^6, or an isomeric body; but it would doubtless be possible, under appropriate conditions, to cause a body constituted in the second manner to split up, by the addition of two atoms of hydrogen, into marsh-gas, CH^4 or , and acetylene, C^2H^2, or 

In the preceding part of this article, we have tried to show that those of the elements which have been sufficiently studied may be divided into distinct classes, according to the manner in which they enter into combination, and further, that each element possesses a certain definite atomic combining capacity, which regulates the formation of its most complex as well as of its simplest compounds. By the application of this principle of the definite atomicity of the elements, it would be easy to construct tables showing all the possible combinations of each element; all compounds whose constitution was sufficiently understood, might then be classified by inserting them in their places in these tables. But since the place of any compound would be determined not only by its composition, but also by the mode or order of combination of its atoms, a point concerning which we have, in most cases, no definite knowledge, such a system of classification would not be widely applicable in the present state of chemistry. Our acquaintance with the great majority of the more complex compounds consists in the knowledge of transformations, by which only a small number of their atoms are affected. It has, therefore, been found convenient, for the purposes of classification to regard such compounds as consisting of two parts, namely, the atom or atoms which take part in their known transformations, and a residue, or nucleus, or radicle, which is unaffected by these transformations, and appears as a constant constituent in all the products to which they give rise. By aid of this convention, the classification founded upon the atomicity of their elements, which, as we have seen, is applicable to the more simple compounds, may be extended so as to comprehend all tolerably well known substances. The radicles, whose existence this view supposes, may be of any degree of complexity; their nature and their relation to the compounds in which they are contained will be most easily understood by considering a few of the simplest of them.

Hydrochloric acid, HCl, water, H^2O, ammonia, H^3N, and marsh-gas, H^4C, have already been shown to be compounds, each of which may be taken as the representative of a whole class of bodies. If we imagine 1 atom of hydrogen to be removed from each of these substances, it is plain that the residues Cl, HO, H^2N, H^3C, will each be able to combine with an atom of hydrogen to reproduce the original compounds, or with some other monatomic atom, such as chlorine or potassium, to form such bodies as:

$$\mathrm{KCl},\ \mathrm{ClCl};\quad \mathrm{KHO},\ \mathrm{ClHO};\quad \mathrm{KH^2N};\quad \mathrm{KH^3C},\ \mathrm{ClH^3C};\ \&c.$$

It is plain also, since 1 at. of a diatomic element is equivalent in combining capacity to 2 monatomic atoms, that 1 at. of oxygen, sulphur, &c., will combine with 2 at. of each of these residues, or with two different residues at once, or with 1 at. of a residue and with 1 at. of a monatomic element, forming such compounds as the following:

$$\mathrm{O}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.,\quad \mathrm{O}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H^3C}\end{matrix}\right.,\quad \mathrm{O}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H^5C^2}{}^{*}\end{matrix}\right.,\quad \mathrm{O}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H}\end{matrix}\right.,\quad \mathrm{O}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{K}\end{matrix}\right.,\ \&c.$$

For similar reasons, it is evident that 1 at. of a triatomic element will combine with 3 at. of such residues, or with 2 at. of residue and 1 at. of a monatomic element, or with 1 at. of residue and 2 monatomic elementary atoms, *e. g.*:

$$\mathrm{N}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.,\quad \mathrm{N}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H^3C}\\ \mathrm{H^3C}\end{matrix}\right.,\quad \mathrm{N}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H^5C^2}\\ \mathrm{H^{11}C^5}{}^{\dagger}\end{matrix}\right.,\quad \mathrm{N}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H^3C}\\ \mathrm{H}\end{matrix}\right.,\quad \mathrm{N}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H}\\ \mathrm{H}\end{matrix}\right.,\ \&c.$$

In like manner, 1 at. of a tetratomic element will combine with 4 at. of residue, or with 4 at. partly of residue and partly elementary, *e. g.*:

$$\mathrm{C}\left\{\begin{matrix}\mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\\ \mathrm{Cl}\end{matrix}\right.,\quad \mathrm{C}\left\{\begin{matrix}\mathrm{H^3C}\\ \mathrm{H}\\ \mathrm{H}\\ \mathrm{H}\end{matrix}\right.,\quad \mathrm{C}\left\{\begin{matrix}\mathrm{HO}\\ \mathrm{H}\\ \mathrm{H}\\ \mathrm{H}\end{matrix}\right.,\quad \mathrm{C}\left\{\begin{matrix}\mathrm{HO}\\ \mathrm{H^3C}\\ \mathrm{H}\\ \mathrm{H}\end{matrix}\right.,\ \&c.$$

From all this it follows that these residues or radicles follow the same laws of combination with the elementary bodies of different classes as do the monatomic elements themselves. Further, they combine also with one another according to the same laws as are followed by elementary monatomic atoms; that is, they combine together in the proportion of 1 at. to 1 at., *e. g.*:

$$\mathrm{Cl} + \mathrm{H^3C} = \underset{\text{Chloride of methyl.}}{\mathrm{ClH^3C}}$$

$$\mathrm{HO} + \mathrm{H^3C} = \underset{\text{Methylic alcohol.}}{\mathrm{OH^4C}}$$

$$\mathrm{H^2N} + \mathrm{H^3C} = \underset{\text{Methylamine.}}{\mathrm{NH^5C}}$$

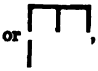
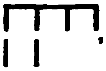
$$\mathrm{H^3C} + \mathrm{H^3C} = \underset{\text{Free methyl.}}{\mathrm{H^6C^2}}$$

But, just as there are not only monatomic but also polyatomic elements, so there are polyatomic as well as monatomic radicles. If we suppose H^2 to be withdrawn from each of the compounds H^2O, H^3N, H^4C, it is evident that the residues O, HN, H^2C, will have the properties of diatomic radicles, the compound radicles HN and H^2C being similar in their combining capacity to the simple radicle O, just as the compound radicles HO, H^2N, and H^3C, resemble the simple radicle Cl in their combining capacity. After the detailed illustration of the properties of the monatomic radicles given above, it is not necessary to dwell upon the characters of the diatomic radicles, since what has been said of the former applies, *mutatis mutandis*, to the latter.

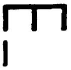
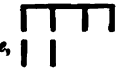
In like manner, the abstraction of H^3 from H^3N and H^4C gives the triatomic radicles N and HC; and the withdrawal of H^4 from any normal compound leaves a tetratomic radicle analogous in properties to the simple radicle C, which results from the withdrawal of H^4 from H^4C.

[*] $H^5C^2 = H^6C^2 - H$: it is a residue or radicle comparable to H^3C.

[†] $H^{11}C^5 = H^{12}C^5 - H$.

Although, in considering the properties and combinations of these or of other compound radicles, we may confine our view to their analogies with the elementary bodies and regard their atomicity as an ultimate property, which, like the atomicity of the elements, is not to be explained, it is easy to see that the atomicity of the radicles of which we have spoken, is the direct result of their composition and the atomicity of their component atoms. It only requires to be put into words to be at once evident that, if one, two, three, or more monatomic atoms be removed from any normal compound whatever, the remainder will be a substance possessing one, two, three, or more units of atomicity free for combining with other bodies, and therefore, as to its power of combination, exactly analogous to an atom of an element whose atomicity is represented by one, two, three, or a higher number. Hence the derivation of any compound radicle determines its atomicity. The maximum atomicity of a radicle may also be always deduced from its composition by means of the formula $A + A' + A'' + \ldots - 2(n - 1)$, in which A, A', A'', &c., indicate the atomicities of the elementary atoms, monatomic as well as polyatomic, of which the radicle is composed, and *n* the number of atoms it contains. From this formula it follows that a compound radicle can never consist of monatomic atoms only; that radicles containing only diatomic atoms are always diatomic; and that the atomicity of radicles containing only tetratomic, or tetratomic and diatomic atoms, is always represented by 2, 4, or some other even number. It follows also from the same formula, and from what has been previously said as to the composition of complex compounds in general, that, starting from the simple radicles already described, there may exist series of radicles of the same atomicity in which the common difference is , *e.g.* O; or , *e.g.* HN; or , *e.g.* CH^2.

For example:

Common difference,		*Common difference,* 		*Common difference,* 		
Cl	O	HO	H	CH^3	CH^2	CH
ClO	SO	PH^2O (in hypophosphites)	NH^2	C^2H^5	C^2H^4	C^2H^3
ClO^2	SO^2			C^3H^7	C^3H^6	C^3H^5
ClO^3				&c.	&c.	&c.
ClO^4						

From these, considered as primary radicles, so-called *derived* or *conjugate* radicles may arise by equivalent substitution; for instance, by substitution of Cl, Br, or I, for H; of O or S for H^2; of S for O; of N for H^3, or for HO^3, &c.; or of NO^2 or NH^2 for H; or of SO^2 or CO for H^2, or generally of any radicle for its equivalent. Again, still other radicles exist differing from these by containing some multiple of H^2 (or its equivalent) less than they do, but possessing the same atomicity; for example, we have ethyl, C^2H^5, and vinyl, C^2H^3; trityl, C^3H^7, and allyl, C^3H^5; propionyl, C^3H^5O, and acryl, C^3H^3O; hexyl, C^6H^{13}, and phenyl, C^6H^5; all of them monatomic radicles.

Hence it follows that triatomic radicles may often be isomeric with monatomic radicles; for example, *acetyl* (Berzelius) C^2H^3, triatomic, with *vinyl*, C^2H^3, monatomic; *glyceryl*, C^3H^5, triatomic, with *allyl*, C^3H^5, monatomic; in like manner, tetratomic and diatomic radicles may be isomeric with each other; for example, *tartryl*, $C^4H^2O^2$, tetratomic (tartaric acid $= \left.\begin{matrix}(C^4H^2O^2)^{iv}\\ H^4\end{matrix}\right\}O^4$), with *fumaryl*, $C^4H^2O^2$, diatomic (fumaric acid $= \left.\begin{matrix}(C^4H^2O^2)''\\ H^2\end{matrix}\right\}O^2$). In such cases, we must suppose that the carbon (or other polyatomic atoms) of the radicles which contain a smaller proportion of hydrogen, or which have a lower atomicity, are more intimately combined with each other than they are in those which, having the same atomicity, contain a larger proportion of hydrogen, or with the same composition have a higher atomicity.

We have hitherto spoken only of the composition and atomicity of compound radicles; it remains to explain a little more fully the grounds upon which their existence in various compounds is assumed, and what that assumption is intended to imply. It has been said that compound radicles are groups of elements which are contained in a greater or lesser number of bodies, and are unaltered in the reactions by which one of these is transformed into another. For instance, the bodies of the following series:—

C^7H^6O	Oil of bitter-almonds,
C^7H^5ClO	Chloride of benzoyl,
$C^7H^6O^2$	Benzoic acid,
C^7H^7ON	Benzamide,
C^8H^5ON	Cyanide of benzoyl

contain the group C^7H^5O (benzoyl) as a common constituent which remains unchanged when they are transformed one into another. Now the reactions by which these transformations are effected are essentially quite similar to those by which the following bodies are changed one into another:—

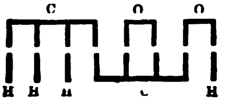
KH (?)	Hydride of potassium.
KCl	Chloride of potassium.
KHO	Hydrate of potassium.
KH^2N	Potassamine.
KCN	Cyanide of potassium.

This analogy is hidden if the formulæ of the bodies of the former series are written as above; but if they are written as containing the compound radicle benzoyl, C^7H^5O, the analogy becomes at once apparent:

$(C^7H^5O)H$	Hydride of benzoyl, or oil of bitter-almonds.
$(C^7H^5O)Cl$	Chloride of benzoyl.
$(C^7H^5O)HO$	Hydrate of benzoyl, or benzoic acid.
$(C^7H^5O)H^2N$	Benzamide.
$(C^7H^5O)CN$	Cyanide of benzoyl.

These latter formulæ express that the bodies represented by them are functionally analogous to compounds of the monatomic elements, and that they respectively possess the general properties of those classes of bodies of which HCl, H^2O, H^3N, &c., are the typical representatives.

The precise nature of the radicle which any substance is represented as containing will naturally vary according as it is desired to express the relations of the substance in question to this or that series of other bodies, or its capability of undergoing this or that series of transformations. If, for example, we wish to express the relation in which acetic acid stands to aldehyde, chloride of acetyl, acetamide, &c., we shall do so most simply by representing it as the hydrate of the compound radicle acetyl, C^2H^3O, thus, $\left.\begin{matrix}C^2H^3O\\H\end{matrix}\right\}O$. But if it be desired to express also that, by distillation with excess of alkali, by electrolysis, or by distillation with arsenious acid, acetic acid is resolved into a compound of the methyl series and a compound of the carbonic series, and that it can be formed from sodium-methyl and carbonic anhydride, or from cyanide of methyl by the action of alkali, this must be expressed by representing the radicle C^2H^3O as composed of the simpler radicles CH^3 and CO; and if we further wish to express the analogy of acetic acid to formic acid, we must write acetyl thus, $C(CH^3)O$, or as formyl, CHO, in which hydrogen is replaced by methyl: the whole formula of acetic acid then becomes $\left.\begin{matrix}C(CH^3)O\\H\end{matrix}\right\}O$. Similarly, in order to express the relations of acetic acid to still other sets of compounds, we are obliged to represent it as containing radicles of continually simpler composition, until finally we come to represent it as built up from elementary atoms; for instance, thus:



Hence the idea of a compound radicle is seen to be entirely relative, the same body from one point of view appearing to contain one compound radicle, and from another point of view appearing to contain a different one. A comparison of the definition of an elementary body, given near the begining of this article, with that of a compound radicle, shows that compound radicles bear the same relation to certain more or less limited sets of chemical processes that the elements bear to all the chemical processes known.

The application of the principles which we have been discussing, to the classification of chemical compounds generally, is illustrated by the following table, which is a modification and extension of that given by Gerhardt (*Traité*, iv. 612, 613), and reproduced in *Graham's Elements of Chemistry* (2nd edit. ii. 528, 529). By referring to the detailed comm ntaries by which Gerhardt's table of classification is followed in the places referred to, the reader will be able to understand fully the meaning of this table without requiring further explanation in this place.

Classification

Compounds comparable to **Hydrochloric Acid,** HCl.				*Compounds comparable*	
Containing monatomic radicles (Chlorides, Hydrides, &c.)	**Containing diatomic radicles (Dichlorides, Dihydrides, &c.)**	**Containing triatomic radicles (Trichlorides, Trihydrides, &c.)**	**Containing tetratomic radicles Tetrachlorides, Tetrahydrides, &c.)**	**Containing monatomic radicles (Oxides, &c.)**	**Containing diatomic radicles (Dioxides, &c.)**
Basic chlorides, hydrides, cyanides, &c.				**Basic oxides, sulphides,**	
Haloïd salts.					
(chloride of potassium, KCl).	(chloride of mercury, $HgCl^2$).	(chloride of antimony, $SbCl^3$).	(chloride of tin, $SnCl^4$).	1. ***Primary***, or ***hydrates*** (hydrate of potassium, KHO).	1. ***Primary*** (hydrate of calcium, CaH^2O^2).
Metallic hydrides (hydride of copper, *&c.*)				2. ***Secondary***, or ***anhydrides*** (oxide of potassium, K^2O).	2. ***Secondary*** (soda-lime, Na^2CaO^2).
Metals proper and alloys.					
(potassium, KK.)	(silver-amalgam.)				
Alcoholic chlorides, hydrides, &c.				**Alcoholic oxides,**	
Halogen ethers.					
(chloride of ethyl, C^2H^5Cl).	(chloride of ethylene, $C^2H^4Cl^2$).	(trichlorhydrine, $C^3H^5Cl^3$)		1. ***Primary*** (common alcohol, $(C^2H^5)HO$).	1. ***Primary*** (glycol, $(C^2H^4)H^2O^2$).
Metallic compounds of alcohol-radicles.					
(potassium-ethyl, KC^2H^5).	(zinc-ethyl, $Zn(C^2H^5)^2$).	(bismethyl, $Bi(C^2H^5)^3$).	(plumbethyl, $Pb(C^2H^5)^4$).	2. ***Secondary*** (common ether, $(C^2H^5)^2O$).	2. ***Secondary.***
				Intermediate oxides,	
				Monatomic oxysalts and ethers (chlorate of potassium, $(ClO^2)KO$; acetate of ethyl, $(C^2H^3O)(C^2H^5)O$).	Diatomic oxysalts and ethers (sulphate of potassium, $(SO^2)K^2O^2$; sulphate of ethyl, $(SO^2)(C^2H^5)^2O^2$)
Acid chlorides, hydrides, &c.				**Acid oxides,**	
Aci-chlorides.					
(chloride of acetyl, $(C^2H^3O)Cl$).	(chloride of succinyl, $(C^4H^4O^2)Cl^2$).	(chloride of phosphoryl, $(PO)Cl^3$).		1. ***Primary*** (acetic acid, $(C^2H^3O)HO$).	1. ***Primary*** (sulphuric acid, $(SO^2)H^2O^2$).
Aldehydes, acetones, &c.					
(acetic aldehyde, $(C^2H^3O)H$; acetone, $(C^2H^3O)(CH^3)$).				2. ***Secondary*** (acetic anhydride, $(C^2H^3O)^2O$).	2. ***Secondary*** (succinate of ethylene, $(C^4H^4O^2)(C^2H^4)O^2$).

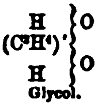
according to Types.

to **Water,** H^2O.		*Compounds comparable to* **Ammonia,** H^3N.			
Containing triatomic radicles (Trioxides, &c.)	Containing tetratomic radicles (Tetroxides, &c.)	Containing monatomic radicles (Amines and Amides).	Containing diatomic radicles (Diamines and Diamides).	Containing triatomic radicles (Triamines and Triamides).	Containing tetratomic radicles (Tetramines and Tetramides).
selenides, &c.		**Basic nitrides, phosphides, arsenides, &c.**			
1. *Primary* (hydrate of bismuth, BiH^3O^3).	1. *Primary*.	1. *Primary* (amide of potassium, KH^2N).	1. *Primary* (zincamide, ZnH^4N^2).	1. *Primary*.	1. *Primary*.
2. *Secondary* (oxide of bismuth, Bi^2O^3).	2. *Secondary*.	2. *Secondary*.	2. *Secondary*.	2. *Secondary*.	2. *Secondary*.
		3. *Tertiary* (nitride of potassium, K^3N).	3. *Tertiary* (nitride of zinc, Zn^3N^2).	3. *Tertiary*.	3. *Tertiary*
sulphides, &c.		**Alcoholic nitrides, phosphides, &c.**			
1. *Primary* (glycerin, $(C^3H^5)H^3O^3$).	1. *Primary*.	1. *Primary* (ethylamine, $(C^2H^5)H^2N$).	1. *Primary* (ethylenediamine, $(C^2H^4)H^4N^2$).	1. *Primary*.	1. *Primary*.
2. *Secondary* (oxide of glyceryl, $(C^3H^5)^2O^3$).	2. *Secondary*.	2. *Secondary* (diethylamine, $(C^2H^5)^2HN$).	2. *Secondary* (diethylenediamine, $(C^2H^4)^2H^2N^2$).	2. *Secondary*.	2. *Secondary*.
		3. *Tertiary* (triethylamine, $(C^2H^5)^3N$).	3. *Tertiary* (triethylenediamine, $(C^2H^4)^3N^2$).	3. *Tertiary*.	3. *Tertiary*.
sulphides, &c.		**Intermediate nitrides, phosphides, &c.**			
Triatomic oxy-salts and ethers (phosphate of bismuth, $(PO)BiO^3$; phosphate of ethyl, $(PO)(C^2H^5)^3O^3$).	Tetratomic oxy-salts and ethers (orthosilicates; orthosilicate of ethyl, $Si(C^2H^5)^4O^4$).	Monalkalamides (ethyl-acetamide, $(C^2H^5)(C^2H^3O)HN$; silver-acetamide, $Ag(C^2H^3O)HN$).	Dialkalamides, (oxanilide, $(C^2O^2)(C^6H^5)^2N^2$).	Trialkalamides (citranilide, $(C^6H^5O^4)(C^6H^5)^3H^3N^3$)	Tetralkalamides.
sulphides, &c.		**Acid nitrides, phosphides, &c.**			
1. *Primary* (phosphoric acid, $(PO)H^3O^3$).	1. *Primary* (tartaric acid, $(C^4H^2O^2)H^4O^4$).	1. *Primary* (acetamide, $(C^2H^3O)H^2N$).	1. *Primary* (oxamide, $(C^2O^2)H^4N^2$).	1. *Primary* (phosphotriamide, $(PO)H^6N^3$).	1. *Primary*.
2. *Secondary* (phosphoric anhydride, $(PO)^2O^3$).	2. *Secondary*.	2. *Secondary* (diacetamide, $(C^2H^3O)^2HN$).	2. *Secondary*.	2. *Secondary*.	2. *Secondary*.
		3. *Tertiary* (dibenzoyl-sulpho-phenylamide, $(C^7H^5O)^2(C^6H^5SO^2)N$).	3. *Tertiary*. (trisuccinamide, $(C^4H^4O^2)^3N^2$).	3. *Tertiary*.	3. *Tertiary*.

The groups into which chemical substances are here divided, may be considered as representing the principal varieties, but they are far from including all chemical compounds. By means of polyatomic radicles, molecules may be built up of much greater complexity than any shown in this table. There appears to be no assignable limit to the number of such compounds or to the degree of complexity which they may reach. Without discussing these bodies at length, we shall be able, by a few examples, to illustrate their nature and their relation to more simple substances. One of the most remarkable series of bodies of the kind to which we refer, are the polyethylenic alcohols of Lourenço and Wurtz. These chemists have shown that glycol, $(C^2H^4)H^2O^2$, is able to fix upon itself the elements of several molecules of oxide of ethylene, so as to give the following series of products:

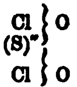
$(C^2H^4)^2H^2O^3$	$(C^2H^4)^3H^2O^4$	$(C^2H^4)^4H^2O^5$	$(C^2H^4)^5H^2O^6$	$(C^2H^4)^6H^2O^7$
Diethylenic alcohol.	Triethylenic alcohol.	Tetrethylenic alcohol.	Pentethylenic alcohol.	Hexethylenic alcohol.

The principal transformations of glycol (monethylenic alcohol) itself are most conveniently expressed by representing it as containing the diatomic radicle ethylene, C^2H^4. With this radicle we must suppose the 2 at. of oxygen contained in glycol to be combined in such a manner that half the combining capacity of each is saturated by half the combining capacity of the radicle, the other half of the combining capacity of each atom of oxygen being saturated by an atom of hydrogen. This view of the constitution of glycol is expressed by the following formula, $\begin{array}{c}H\\(C^2H^4)''\\H\end{array}\left\}\begin{array}{c}O\\ \\O\end{array}\right.$. Thus regarded, glycol may be compared to water by representing it as two molecules of water in which H^2 is replaced by $(C^2H^4)''$. The polyethylenic alcohols then become comparable to glycol if viewed as 3, 4, 5, &c., molecules of water in which respectively $(C^2H^4)^2$, $(C^2H^4)^3$, $(C^2H^4)^4$, &c., replaces an equivalent quantity of hydrogen. This comparison is expressed by the formulæ by which these compounds are represented above; but their relation to glycol becomes perhaps still more apparent if the same formulæ be written a little differently, so as to be directly comparable with that last given for glycol. Below are the formulæ of some of them so written, side by side with sulphur-compounds, which may be regarded as of analogous constitution.



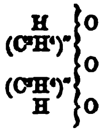
$$\begin{array}{c}H\\(C^2H^4)'\\H\end{array}\left\}\begin{array}{c}O\\ \\O\end{array}\right.$$

Glycol.



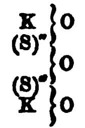
$$\begin{array}{c}Cl\\(S)''\\Cl\end{array}\left\}\begin{array}{c}O\\ \\O\end{array}\right.$$

Chlorosulphuric acid.



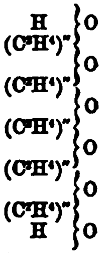
$$\begin{array}{c}H\\(C^2H^4)''\\ \\(C^2H^4)''\\H\end{array}\left\}\begin{array}{c}O\\ \\O\\ \\O\end{array}\right.$$

Diethylenic alcohol ($= C^4H^{10}O^3$).



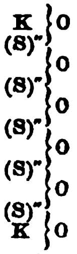
$$\begin{array}{c}K\\(S)''\\ \\(S)''\\K\end{array}\left\}\begin{array}{c}O\\ \\O\\ \\O\end{array}\right.$$

Hyposulphite of potassium ($= S^2K^2O^3$).



$$\begin{array}{c}H\\(C^2H^4)''\\ \\(C^2H^4)''\\ \\(C^2H^4)''\\ \\(C^2H^4)''\\H\end{array}\left\}\begin{array}{c}O\\ \\O\\ \\O\\ \\O\\ \\O\end{array}\right.$$

Pentethylenic alcohol ($= C^{10}H^{22}O^6$).



$$\begin{array}{c}K\\(S)''\\ \\(S)''\\ \\(S)''\\ \\(S)''\\K\end{array}\left\}\begin{array}{c}O\\ \\O\\ \\O\\ \\O\\ \\O\end{array}\right.$$

Pentathionate of potassium ($= S^5K^2O^6$).

After these remarks, and what has been previously said about the combinations of polyatomic elements and radicles in general, the following table will be intelligible without further explanation. It gives a list (probably almost complete) of the known compounds containing two or more atoms of the same carbonated radicle, and a few examples of compounds containing radicles composed of other elements, such as sulphuryl (SO^2) and phosphoryl (PO). Many other examples of compounds of a similar nature might be found among mineral substances both natural and artificial, and there can be little doubt that the complex silicates and other minerals belong to this class of compounds. In the table, compounds of the same radicle are arranged on the same horizontal line; those referable to the same type are arranged in the same vertical column.

Classification according to Types (continued).

	Compounds referable to the type H^6O^3.	Compounds referable to the type H^8O^4.	Compounds referable to the type $H^{10}O^5$.	Compounds referable to the type $H^{12}O^6$.	Compounds referable to the type $H^{14}O^7$.	Compounds referable to the type $\left.\begin{matrix}H^8O^4\\HCl\end{matrix}\right\}$.	Compounds referable to the type $\left.\begin{matrix}H^4O^2\\H^3N\end{matrix}\right\}$	Compounds referable to the type $\left.\begin{matrix}H^8O^3\\H^3N\end{matrix}\right\}$.	Compounds referable to the type $\left.\begin{matrix}H^4O^2\\HCl\\H^3N\end{matrix}\right\}$.
Compounds containing the radicle *ethylene*, $(C^2H^4)''$.	$\left.\begin{matrix}(C^2H^4)^2\\H^2\end{matrix}\right\}O^3$ Lourenço.	$\left.\begin{matrix}(C^2H^4)^3\\H^2\end{matrix}\right\}O^4$ Wurtz, Lourenço.	$\left.\begin{matrix}(C^2H^4)^4\\H^2\end{matrix}\right\}O^5$ Wurtz Lourenço.	$\left.\begin{matrix}(C^2H^4)^5\\H^2\end{matrix}\right\}O^6$ Wurtz, Lourenço.	$\left.\begin{matrix}(C^2H^4)^6\\H^2\end{matrix}\right\}O^7$ Lourenço.		$\left.\begin{matrix}(C^2H^4)^2\\H^3\end{matrix}\right\}\begin{matrix}O^2\\N\end{matrix}$ Wurtz.	$\left.\begin{matrix}(C^2H^4)^3\\H^3\end{matrix}\right\}\begin{matrix}O^3\\N\end{matrix}$ Wurtz.	
Compounds containing the radicle *glycolyl*, $(C^2H^2O)''$.	$\left.\begin{matrix}(C^2H^2O)^2\\H^2\end{matrix}\right\}O^3$ Wurtz, Heintz.	$\left\{\begin{matrix}(C^2H^2O)^2\\(C^2H^4)H^2\end{matrix}\right\}O^4$ Wurtz.							
Compounds containing the radicle *lactyl*, $(C^3H^4O)''$.	$\left.\begin{matrix}(C^3H^4O)^2\\H^2\end{matrix}\right\}O^3$ Pelouze. $\left\{\begin{matrix}(C^3H^4O)^2\\(C^2H^5)H\end{matrix}\right\}O^3$ Wurtz and Friedel.	$\left\{\begin{matrix}(C^3H^4O)^3\\(C^2H^5)H\end{matrix}\right\}O^4$ Wurtz and Friedel. $\left\{\begin{matrix}(C^3H^4O)^2\\(C^2H^5)^2\end{matrix}\right\}O^4$ Wurtz and Friedel. $\left.\begin{matrix}(C^3H^4O)^2\\(C^4H^4O^4)^2\\(C^2H^5)^2\end{matrix}\right\}O^4$ Wurtz & Friedel.							
Compounds containing the radicle *anisalyl*, $(C^8H^8)''$.							$\left.\begin{matrix}(C^8H^8)^2\\H^3\end{matrix}\right\}\begin{matrix}O^2\\N\end{matrix}$ Cannizzarro.		
Compounds containing the radicle *sulphuryl*, $(SO^2)''$.	$\left.\begin{matrix}(SO^2)^2\\H^2\end{matrix}\right\}O^3$ (Nordhausen sulphuric acid).						$\left\{\begin{matrix}(SO^2)^2\\(C^6H^5)H^2\end{matrix}\right\}\begin{matrix}O^2\\N\end{matrix}$ Carius. $\left\{\begin{matrix}(SO^2)^2\\(C^7H^7)H^2\end{matrix}\right\}\begin{matrix}O^2\\N\end{matrix}$ Carius. $\left\{\begin{matrix}(SO^2)^2\\(C^9H^{11})H^2\end{matrix}\right\}\begin{matrix}O^2\\N\end{matrix}$ Carius.		
Compounds containing the radicle *glyceryl*, $(C^3H^5)'''$.		$\left.\begin{matrix}(C^3H^5)^2\\H^2\end{matrix}\right\}O^4$ Lourenço.	$\left.\begin{matrix}(C^3H^5)^2\\H^4\end{matrix}\right\}O^5$ Lourenço. $\left\{\begin{matrix}(C^3H^5)^2\\(C^2H^5)^3H\end{matrix}\right\}O^5$ Reboul and Lourenço.	$\left.\begin{matrix}(C^3H^5)^2\\H^6\end{matrix}\right\}O^6$ Lourenço.	$\left.\begin{matrix}(C^3H^5)^3\\H^5\end{matrix}\right\}O^7$ Lourenço. $\left\{\begin{matrix}(C^3H^5)^3\\(C^2H^5)^4H\end{matrix}\right\}O^7$ Reboul and Lourenço.	$\left\{\begin{matrix}(C^3H^5)^2\\(C^2H^5)^2\\H\end{matrix}\right\}\begin{matrix}O^4\\Cl\end{matrix}$ Reboul and Lourenço.			$\left.\begin{matrix}(C^3H^5)^2\\H^2\end{matrix}\right\}\begin{matrix}O^2\\Br\\N\end{matrix}$ Berthelot and de Luca.
Compounds containing the radicle *phosphoryl*, $(PO)'''$.		$\left.\begin{matrix}(PO)^2\\Na^2\end{matrix}\right\}O^4$ Maddrell. (Insoluble metaphosphate.)	$\left.\begin{matrix}(PO)^2\\Na^4\end{matrix}\right\}O^5$ Clark. (Pyrophosphate.)	$\left.\begin{matrix}(PO)^3\\Na^3\end{matrix}\right\}O^6$ Fleitmann and Henneberg.					

Classification according to Types (continued).

	Compounds referable to the type H^9N^3.	Compounds referable to the type $H^{12}N^4$.
Compounds containing the radicle *ethylene*, $(C^2H^4)''$ (*continued*).	$\left.\begin{matrix}(C^2H^4)^2\\H^5\end{matrix}\right\}N^3$	$\left.\begin{matrix}(C^2H^4)^3\\H^6\end{matrix}\right\}N^4$
	$\left.\begin{matrix}(C^2H^4)^2\\(C^2H^5)^2\\H^3\end{matrix}\right\}N^3$	$\left.\begin{matrix}(C^2H^4)^3\\(C^2H^5)^6\end{matrix}\right\}N^4$
	$\left.\begin{matrix}(C^2H^4)^2\\(C^2H^5)^3\\H^2\end{matrix}\right\}N^3$	$\left.\begin{matrix}(C^2H^4)^5\\(C^2H^5)^2\end{matrix}\right\}N^4$
	$\left.\begin{matrix}(C^2H^4)^3\\H^3\end{matrix}\right\}N^3$	$(C^2H^4)^6N^4$
	$\left.\begin{matrix}(C^2H^4)^3\\(C^2H^5)^3\end{matrix}\right\}N^3$	
	Hofmann.	Hofmann.

A little reflection upon what has been said (p. 1017) on the nature of compound radicles, and on the sense in which they are employed, will make it clear that a classification of compounds by means of them, according to types, such as that illustrated in the two tables given, pp. 1018, 1019, 1021, 1022, expresses all we know of their general chemical properties. For the classification of a number of substances as containing the same radicle, expresses that they are mutually convertible by comparatively simple processes, that is, that they are *genetically* related,—while the classification of any set of bodies by reference to the same type, expresses that they are capable of undergoing similar transformations, and are therefore *functionally* related. All our strictly chemical knowledge, however, consists in a knowledge (1) of the nature and proportion of the elements of which substances are composed; (2) of their genetic relations, or of the bodies from which they can be formed, or to which they can give rise; and (3) of their chemical functions, or the transformations which they cause or undergo when they react with other bodies. In the foregoing pages, we have accordingly endeavoured to point out the leading principles which must be kept in view in classifying chemical substances with reference to considerations of each of these three kinds, considering however at the greatest length the classification of bodies according to their composition; partly because much less attention has been paid to this subject, in the existing literature of chemistry, than to their genetic and functional relations, but chiefly because composition is the most fundamental of all chemical properties, and the manner in which all other chemical properties depend upon it is the fundamental problem of chemistry. Throughout, we have endeavoured to distinguish between ideas and mere forms of expression, rendered convenient by the existing state of the science.

The order and system which has been followed in this article, has made it impossible to trace the historical development of the ideas therein set forth. The following list of Memoirs of theoretical importance will be of assistance to such readers as wish to trace that development from the birth of Organic Chemistry to the present time: many other memoirs of equal importance with some of those enumerated, might have been quoted; but in a large number of these, references are given which will serve as a guide to those who wish to pursue the subject further.

Lavoisier (*Compound radicles*), Traité élémentaire de Chimie (edit. 1789), i. 197, 209.

Dumas and Boullay (*Compound ethers*), Ann. Ch. Phys. xxxvii. 15 (1828).

Wöhler and Liebig (*Benzoyl compounds*), Ann. Ch. Pharm. iii. 249 (1832); Ann. Ch. Phys. li. 273.

Berzelius (*Radicle of the benzoic compounds*), Ann. Ch. Pharm. iii. 282; Ann. Ch. Phys. li. 308.

Berzelius (*Radicles of alcohol and its derivatives*), Jahresber. (1833), xiii. 189; Pogg. Ann. xxviii. 617; Ann. Ch. Phys. liv. 5; extract, Ann. Ch. Pharm. vi. 173.

Liebig (*Ethyl*), Handwörterb. d. Chemie (1^{te} Auflage), article *Æther;* Ann. Ch. Pharm. ix. 1; Pogg. Ann. xxxi. 321; Ann. Ch. Phys. lv. 113 (1834).

Liebig (*Acetyl, constitution of acetic acid*, &c.), Ann. Ch. Pharm. xiv. 133 (1835); Pogg. Ann. xxxvi. 275.

Dumas (*Substitution*), Ann. Ch. Phys. lvi. 143 (1835); Traité de Chimie appliquée aux Arts, v. 99; J. pr. Chem. vii. 293.

Laurent (*Nucleus theory*), Ann. Ch. Phys. lxi. 126 (1836).

Gerhardt (*Conjugated compounds*), *ibid.* lxxii. 184 (1838).

Dumas (*Substitution*), Compt. rend. x. 149; Ann. Ch. Pharm. xxxiii. 259 (1839).

Gerhardt (*Atomic weights of oxygen, carbon, &c.*), Ann. Ch. Phys. [3] vii. 129; viii. 238; Précis de Chimie organique (1844), i. 47.

Gerhardt (*Homology*), Précis, ii. 489.

Laurent (*Law of even numbers of atoms; nature of the elements in the free state; monads and dyads*), Ann. Ch. Phys. [3] xviii. 266 (1846); Chemical Method, 46—96, *et passim.*

Wurtz (*Compound ammonias*), Compt. rend. xxviii. 233, 323 (1849); xxix. 169; Ann. Ch. Phys. [3] xxx. 443; Chem. Soc. Qu. J. iii. 90.

Hofmann (*Compound ammonias*), Phil. Trans. 1850, i. 93; Chem. Soc. Qu. J. iii. 279.

Williamson (*Mixed ethers, etherification*), Chem. Soc. Qu. J. iv. 106, 229 (1851).

Williamson (*Constitution of salts*), Chem. Soc. Qu. J. ix. 350 (1851).

Gerhardt and Chancel (*Constitution of organic compounds*), Compt. chim. (1851), vii. 65.

Gerhardt (*Basicity of acids*), Compt. chim. (1851), vii. 129.

Gerhardt (*Anhydrous organic acids; classification by types*), Compt. rend. xxxiv. 755, 902 (1852); Chem. Soc. Qu. J. v. 127, 226; more fully Ann. Ch. Phys. [3] xxxvii. 285; Dumas's Report, Compt. rend. xxxvi. 505.

Berthelot (*Synthesis of fats; nature of glycerine*), Ann. Ch. Phys. xli. 216 (1853—54).

Odling (*Constitution of salts; polyatomic radicles*), Chem. Soc. Qu. J. vii. 1 (1854).

Wurtz (*Theory of glycerine-compounds; polyatomic radicles*), Ann. Ch. Phys. [3] xliii. 493 (1855).

Wurtz (*Mixed radicles*), *ibid.* xliv. 275.

Gerhardt and Chiozza (*Amides*), *ibid.* xlvi. 129 (1855—56).

H. L. Buff (*Polyatomic radicles*), Proc. Roy. Soc. viii. 188 (1856).

Wurtz (*Diatomic alcohols*), Compt. rend. xliii. 199; Ann. Ch. Pharm. c. 110; more fully, Ann. Ch. Phys. [3] lv. 400 (1856—59).

Kekulé (*Mixed types, radicles, &c.*), Ann. Ch. Pharm. civ. 129 (1857).

Kekulé (*Ditto; tetratomic character of carbon*), *ibid.* cvi. 129 (1858).

Couper (*Atomicity of carbon and oxygen*), Ann. Ch. Phys. [3] liii. 504 (1858); Ann. Ch. Pharm. cx. 46 (here followed by critique by Buttlerow, 1859).

Kolbe (*Constitution of lactic acid*), Ann. Ch. Pharm. cix. 257 (1859); same subject, *ibid.* cxiii. 223 (1860).

Foster (*Nature of radicles and types*), Brit. Assoc. Reports, 1859, 1.

Wurtz (*Basicity of acids*), Ann. Ch. Phys. [3] li. 342 (1859).

Cahours (*Combining capacity of the elements; limits of combination*), Ann. Ch. Phys. [3] lviii. 5 (1860).

Frankland (*Same subject*), Chem. Soc. Qu. J. xiii. 177 (1860).

Wurtz (*Constitution of lactic acid*), Ann. Ch. Phys. [3] lix. 161 (1860).

Cahours (*Same subject*), Ann. Ch. Phys. [3] lxii. 257 (1861).

Buttlerow (*Atomicity of the elements*), Zeitschr. Chem. Pharm. iv. 549 (1861).

Erlenmeyer (*Same subject*), *ibid.* v. 18 (1862).

Kolbe (*Classification of organic bodies*), Ann. Ch. Pharm. cxiii. 293 (1860); Critical remarks by Wurtz, Rép. Chim. pure, ii. 354.

Laurent, Méthode de Chimie, 1854; Cavendish Society's translation, 1855.

Gerhardt, Traité de Chimie organique, 4 vols. 1853—56; especially i. pp. 121—142. iv. pp. 561—808.

Kekulé, Lehrbuch der organischen Chemie, vol. i. (1859—61).

Odling, Manual of Chemistry, part i. (1861). G. C. F.

CLAUSTHALITE. Native selenide of lead. (See LEAD.)

CLAY. This term is applied to hydrous silicates of aluminium, produced for the most part by the decomposition of felspar rocks, and generally mixed with small quantities of other substances, chiefly lime, magnesia, and oxide of iron. The clays exhibit the following general characters:—They are opaque, non-crystallised bodies, sufficiently soft to be scratched by iron; they have a dull or even earthy fracture; they exhale, when breathed on, a peculiar smell called argillaceous. The clays form with water a plastic paste, possessing considerable tenacity, which hardens with heat, so as to strike fire with steel. Marls and chalks also soften in water, but their paste is not tenacious, nor does it acquire a siliceous hardness in the fire. The affinity of the clays for moisture is manifested by their sticking to the tongue, and by the intense heat necessary to make them perfectly dry. Those which contain iron turn red when burnt. Clay is often mixed with quartz, and contains fine particles of felspar, mica, and beryl, showing that it has been produced by the decomposition of felspar or granite.

The principal varieties of clay are the following:

1. *Porcelain earth*, the kaolin of the Chinese.—This mineral is friable, meagre to the touch, and, when pure, forms with difficulty a paste with water. It is infusible in a porcelain furnace. It is of a pure white, verging sometimes upon the yellow or flesh-red. Some varieties exhibit particles of mica, which betray their origin to be from felspar or graphite granite. Porcelain clay scarcely adheres to the tongue. Specific gravity 2·2. The average composition of kaolin, when separated from free silica and undecomposed felspar, is 47 per cent. silica, 40 alumina, and 13 water, agreeing with the formula $Al^4O^3.2SiO^2 + 2$ aq. It may be supposed to be formed from orthoclase, $K^2O.Al^4O^3.6SiO^2$, by abstraction of the whole of the potash and ⅔ of the silica, and addition of 2 at. water. Some varieties, however, exhibited a different composition; thus the kaolin of Passau contains, according to Fuchs, 43·65 per cent. SiO^2, 35·93 Al^4O^3, 1·00 Fe^4O^3, and 18·50 water, besides 0·88 carbonate of calcium, a composition which may be approximately represented by the formula $4Al^4O^3.9SiO^2 + 12$ aq. Porcelain clay from Gutenberg, near Halle, contains, according to Bley, 39·02 SiO^2, 45·00 Al^4O^3, and 10·00 water, together with 0·07 carbonate of calcium, 3·32 carbonate of magnesium, and 0·19 sesquioxide of iron, agreeing approximately with $2Al^4O^3.3SiO^2 + 3$ aq. (*Rammelsberg's Mineralchemie*, p. 574). In two specimens of Chinese kaolin, Ebelmen and Salvétat (Ann. Ch. Phys. xxxi. 257) found 73·4 and 80·7 SiO^2, 44·5 Al^4O^3, 14·4 and 12·0 water; in these the quantity of silica is twice as great, in proportion to the alumina, as in the ordinary formula of kaolin (Dana, ii. 250). Kaolin is found in primitive mountains, amid blocks of granite, forming interposed strata. Kaolins are sometimes preceded by beds of a micaceous rock of the texture of gneiss, but red and very friable. This remarkable disposition has been observed in the kaolin quarries of China, in those of Alençon, and of St. Yrieux, near Limoges. The Chinese and Japanese kaolins are whiter and more unctuous to the touch than those of Europe. The Saxon has a slight tint of yellow or carnation, which disappears in the fire, and therefore is not owing to metallic impregnation. At St. Yrieux, the kaolin is in a stratum, and also in a vein, amid blocks of granite, or rather the felspar rock which the Chinese call *petuntze*. The Cornish kaolin is very white and unctuous to the touch, and is obviously formed by the disintegration of the felspar of granite.

2. *Potters' clay*, or *plastic clay*.—The clays of this variety are compact, smooth, and almost unctuous to the touch, and may be polished by the finger when they are dry. They have a great affinity for water, form a tenacious paste, and adhere strongly to the tongue. The paste of some is even slightly transparent. They acquire great solidity, but are infusible in the porcelain furnace. This property distinguishes them from the common clays employed for coarse earthenware. Some of them remain white, or become so in a high heat; others turn red. Specific gravity about 2. The slaty potters' clay of Werner has a dark ash-grey colour; principal fracture imperfectly conchoïdal, cross fracture earthy; fragments tabular, rather light; it feels more greasy than common potters' clay. Vauquelin's analysis of the plastic clay of Forges-les-Eaux, employed for making glass-house pots, as well as pottery, gave 16 alumina, 63 silica, 1 lime, 8 iron, and 10 water. Another potters' clay gave 33·2 and 43·5, of alumina and silica, with 3·5 lime.

Fire-clay is a very refractory plastic clay, much used in the manufacture of fire-bricks, glass-house pots, &c. In this country it lies immediately beneath the coal, each bed of which rests upon a stratum of this clay, hence called in the mining districts *under-clay*. The Stourbridge clay is of this character. (See FIRE-CLAY.)

3. *Loam*.—This is an impure potters' clay mixed with mica and iron ochre. Colour yellowish-grey, often spotted yellow and brown. Massive, with a dull glimmering lustre from scales of mica. Adheres pretty strongly to the tongue, and feels slightly greasy. Its density is inferior to the preceding.

4. *Variegated clay* is striped or spotted with white, red, or yellow. Massive, with an earthy fracture, verging on slaty. Shining streak. Very soft, sometimes even friable. Feels slightly greasy, and adheres a little to the tongue. Sectile. It is found in Upper Lusatia.

5. *Slate clay*.—Colour grey, or greyish-yellow. Massive. Lustre dull or glimmering from interspersed mica. Fracture slaty, approaching sometimes to earthy. Fragments tabular. Opaque, soft, sectile, and easily broken. Specific gravity 2·6. Adheres to the tongue, and breaks down in water. It is found along with coal, and in the floetz trap formation.

6. *Claystone.*—Colour grey, of various shades, sometimes red, and spotted or striped. Massive. Lustre dull, with a fine earthy fracture, passing into fine-grained uneven, slaty, or splintery. Opaque, soft, and easily broken. Does not adhere to the tongue, and is meagre to the touch. It has been found on the top of the Pentland hills in Scotland, and in Germany.

7. *Adhesive slate.*—Colour light greenish-grey. Internal lustre dull; fracture in the large, slaty; in the small, fine earthy. Fragments slaty. Opaque. Streak shining. Sectile. Easily broken or exfoliated. Adheres strongly to the tongue, and absorbs water rapidly, with emission of air bubbles and a crackling sound. It is found at Montmartre, near Paris, between blocks of impure gypsum, in large straight plates like sheets of pasteboard; also at Menilmontant, enclosing menilite. Klaproth's analysis gives 62·5 silica, 8 magnesia, 0·5 alumina, 0·25 lime, 4 oxide of iron, 22 water, and 0·75 charcoal. Its specific gravity is 2·08.

8. *Polishing slate* of Werner.—Colour cream-yellow, in alternate stripes. Massive. Lustre dull. Slaty fracture. Fragments tabular. Very soft, and adheres to the tongue. Smooth, but meagre to the touch. Specific gravity in its dry state 0·6 when imbued with moisture 1·9. It has been found only in Bohemia. Its constituents are, 79 silica, 1 alumina, 1 lime, 4 oxide of iron, and 14 water.

9. *Common clay* may be considered to be the same as *loam.*—Besides the above, we have the analyses of some pure clays, the results of which show a very minute quantity of silica, and a large quantity of sulphuric acid. Thus, in one analysed by Bucholz, there was 1 silica, 31 alumina, 0·5 lime, 0·5 oxide of iron, 21·5 sulphuric acid, 45 water, and 1·5 loss. Simon found 19·35 sulphuric acid in 100 pts. These clays must be regarded as basic sulphates of aluminium. U.

For analysis of various clays, see *Ure's Dictionary of Arts, Manufactures and Mines,* i. 691.

CLAY-SLATE. *Argillaceous schist;* the *Argillite* of Kirwan.—Colour bluish-grey and greyish-black of various shades. Massive. Internal lustre shining or pearly. Fracture foliated. Fragments tabular. Streak greenish-white. Opaque. Soft. Sectile. Easily broken. Sonorous when struck with a hard body. Specific gravity 2·7. Its constituents are 48·6 silica, 23·5 alumina, 1·6 magnesia, 11·3 sesquioxide of iron, 0·5 oxide of manganese, 4·7 potash, 0·3 carbon, 0·1 sulphur, 7·6 water and volatile matter. Clay-slate melts easily before the blowpipe into a shining scoria. This mineral is extensively distributed, forming part of both primitive and transition mountains. The great beds of it are often cut across by thin seams of quartz or carbonate of lime, which divide them into rhomboïdal masses. Good slates should not imbibe water. If they do, they soon decompose by the weather. U.

CLAY IRON-STONE. See Iron.

CLAYITE. A mineral from Peru, occurring crystallised and as a crust ⅜ of an inch thick on quartz. It appears to be composed of the sulpharsenites of copper and sulphantimonites of copper and lead. The crystals belong to the regular system, being combinations of the tetrahedron with the rhombic dodecahedron. Colour blackish-grey. Streak the same. Lustre metallic. Hardness = 2·5. Sectile. Melts easily before the blowpipe, and gives the reactions of lead, arsenic, and antimony. With soda it yields a metallic globule, which becomes dull on cooling. Possibly a pseudomorph of fahl-ore. (W. J. Taylor, Sill. Am. J. [2] xxix. 367.)

CLEAVAGE OF CRYSTALS. See Crystallography.

CLEAVELANDITE. Soda-felspar. (See Felspar.)

CLEOPHANE. Syn. with blende or native sulphide of zinc. (See Zinc).

CLEMATIS-CAMPHOR. The young branches of *Clematis flammula, Cl. vitalba, Cl. vitioella, Cl. erecta,* &c., yield by distillation with water, a liquid which has a sharp taste, a pungent odour of radish, and reddens the skin; when exposed to the air, it loses its acidity, and if left to stand in closed vessels, deposits white scales and flocks of clematis-camphor. (Braconnot, Ann. Ch. Phys. vi. 734.)

CLEMATITIN. A bitter substance, perhaps $C^9H^{10}O^6$, obtained by Walz from the root of *Aristolochia clematitis* (i. 357).

CLINGMANNITE. Syn. with Margarite (*q. v.*)

CLINKSTONE or **PHONOLITE** is a compact felspathic rock, of greyish colour and smooth fracture, clinking when struck with a hammer, somewhat like a metal. Specific gravity = 2·2 – 2·4.

CLINOCHLORE. A mineral having the same composition as chlorite (i. 913), but differing from it in crystalline form, inasmuch as it belongs to the trimetric system, whereas chlorite is rhombohedral. The crystals of clinochlore are hemihedral, and have a micaceous structure, the crystallising planes often forming equilateral triangles. It is optically biaxial, the angle between the axes being 84° 30′ (or 80° to 86°); the plane of the axes is perpendicular to the cleavage-surface, but the two axes are unequally inclined to this surface, one at 54° the other at 30°. It occurs in large crystals, usually having a rhombohedral aspect, and in plates; often compounded, the crystals giving a second pair of optical axes, making an angle of 60° with the other. Specific gravity about 2·714. Hardness 2—2·5. Lustre somewhat pearly. Colour olive-green. Transparent, unless in thick plates. Somewhat elastic.

Analyses.—*a*, *b*, from Chester county, Pennsylvania, by W. J. Craw (Sill. Am. J. [2] xiii. 222); *c*, from Lisgau, Bavaria, Kobell (Gel. Anzeige, 1854, No. 43):

	SiO^2	Al^2O^3	Fe^2O^3	Cr^2O^3	$Mg''O$	H^2O
a.	31·34	17·47	3·85	1·69	33·44	12·60 = 100·39
b.	31·78		22·71		33·64	12·60 = 100·72
c.	33·49	15·87	2·30	0·55	32·94	11·50 Fe^2O 4·25 = 100·40

Before the blowpipe it behaves like chlorite, showing traces of fusion on the edges. (Dana, ii. 294.)

CLINOCLASE. Syn. with ABICHITE (i. 1).

CLINTONITE. *Seybertite, Holmesite, Chrysophane.*—A silicate found at Amity, New York, in limestone connected with serpentine, together with augite, hornblende, spinel, and graphite. It forms small tabular crystals or foliated masses, sometimes lamellar, radiate. Structure thin, foliated, or micaceous, parallel to the base. According to Breithaupt, the crystals are monoclinic, with the angles between the lateral planes = 94°. Specific gravity = 3—3·1. Hardness = 4—5. Lustre pearly, submetallic. Colour reddish-brown, yellowish or copper-red. Streak uncoloured, or slightly yellowish or greyish. Folia brittle.

Closely allied to clintonite are *Xanthophyllite*, from Slatoust in the Ural, where it occurs in implanted globules, and in columnar or lamellar individuals, sometimes enclosing small hexagonal crystals secondary to a rhombic prism, and *Disterrite* or *Brandisite*, occurring in the Fassa valley, Tyrol, in hexagonal prisms of specific gravity 3·042—5·051, and hardness = 5 on the base, 6—6·5 on the sides.

Analyses.—*a*, *Seybertite*, by Clemson (Sill. Am. J. xxiv. 171).—*b*, *Holmesite*, by Richardson (Rec. Gen. Sci. May, 1836).—*c*, Clintonite, by Brush (Sill. Am. J. [2] xviii. 407).—*d*, *Xanthophyllite*, by G. Rose (Pogg. Ann. i. 654).—*e*, *Disterrite* or *Brandisite*, by Kobell (J. pr. Chem. xli. 154):

	SiO^2	ZrO^2	Al^2O^3	$Fe''O^3$	$Mn''O$	$Mg''O$	$Ca''O$	K^2O	Na^2O	H^2O	F	
a	17·0		37·6	5·5	—	24·3	10·7	—	—	3·6	—	= 98·7
b	19·35	2·05	44·75	4·80	1·35	9·05	11·45	—	—	4·55	0·90	= 98·25
c	20·18	0·19	38·90	3·87	—	21·25	13·52	0·29	1·14	1·04	—	= 100·41
d	16·30	—	43·95	2·81	—	19·31	13·26	—	0·61	4·33	—	= 100·57
e	20·00	—	43·22	3·60	—	25·01	4·00	0·57	—	3·60	—	= 100

These results may be approximately represented by the following formulæ, in which M denotes a uni-equivalent and R a triequivalent metal:—

Clintonite (Seybertite, Holmesite)	$2M''O.3SiO^2 + 2(3M''O.2R^2O^3)$
Xanthophyllite	$2M''O.3SiO^2 + 3(3M''O.2R^2O^3) + 3aq.$
Disterrite	$2M''O.3SiO^2 + 4(M''O.R^2O^3) + 2aq.$

It is doubtful whether either of these minerals has been found in an unaltered state.

Clintonite is infusible before the blowpipe, but loses its brown colour and becomes opaque; heated in a flask it gives off neutral water. It is completely decomposed by hydrochloric acid.

Xanthophyllite yields green glasses with fluxes: it is decomposed by acids, like clintonite, but much less easily.

Disterrite when heated gives off water, which is neutral or alkaline, according as the specimen is fresh or has turned red-brown by weathering. Before the blowpipe it becomes turbid and greyish-white, but does not fuse; with fluxes it gives the reactions of iron and silica. It is not sensibly attacked by hydrochloric acid: but sulphuric acid decomposes it when heated with it for some time. (*Rammelsberg's Mineralchemie*, p. 848.—Dana, ii. 297.)

CLOUDS are masses of air which contain innumerable minute particles of suspended water condensed from a state of vapour, and thus assume the appearance of white or misty bodies. The forms of clouds, which of course depend on the form and motions of the mass of air, were first properly classified by Howard, (*Rees' Cyclopædia*, art. CLOUD; *Nicholson's Journal*, 1811, xxx. 35—62; or *Howard's Climate of London*, 2nd ed. vol. i.), whose arrangement we may thus shortly describe.

Cirrus.—Parallel, flexuous, or diverging fibres, commonly called *mare-tails*, occurring most distinctly in the higher regions of the atmosphere, but sometimes originating from large masses of other cloud at lower elevations. The adjective *cirrose* may be applied to any streaked appearance in clouds.

Cumulus.—Convex or conical heaps, increasing upward from a horizontal base. This is the most abundant form of cloud, generally appearing during the day at a moderate elevation, and moving along with the current next the earth.

Stratus.—A widely extended continuous horizontal sheet, either lying upon the surface of the earth as a mist, or elevated at any height in the atmosphere.

Cirrostratus.—Stratus streaked with the fibres of the cirrus. This form of cloud, generally occurring at a great elevation, and consisting, therefore, of particles of ice, is the cause of solar and lunar halos, and also of the parhelion and paraselene.

Cumulostratus.—A cumulus the summit of which spreads laterally, producing an anvil-shaped cloud. This kind of cloud is very likely to turn to the following:

Nimbus, *Cumulo-cirro-stratus*, *Rain*, or *Thundercloud* is a cloud or system of clouds forming a great sheet or mass, mostly cumulose, but with lateral stratose extensions, and with tufts of cirrus spreading from the summit. It indicates a great disturbance of the atmosphere, caused by a violent upward current in the centre of the cloud, and is generally accompanied by wind or squalls.

The following further statements are on the authority of Howard.

The *cumulus* has the densest structure, and is formed in the lower atmosphere. A small irregular spot first appears, and is, as it were, the nucleus on which the mass increases. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps, which may afterwards long continue nearly of the same bulk, or rapidly rise into mountains. They will begin, in fair weather, to form some hours after sunrise, arrive at their maximum in the hottest part of the afternoon, then go on diminishing, and totally disperse about sunset. Previous to rain, the cumulus increases rapidly, appears lower in the atmosphere, and with its surface full of loose fleeces or protuberances. The formation of large cumuli to leeward in a strong wind indicates the approach of a calm with rain. When they do not disappear or subside about sunset, but continue to rise, thunder is to be expected in the night.

The *stratus* has a mean degree of density, and is the lowest of clouds, its inferior surface commonly resting on the earth or water. This is properly the cloud of night, appearing about sunset. It comprehends all those creeping mists, which in calm weather ascend in spreading sheets (like an inundation of water), from the bottom of valleys and the surfaces of lakes and rivers. On the return of the sun, the level surface of this cloud begins to put on the appearance of cumulus, the whole at the same time separating from the ground. The continuity is next destroyed, and the cloud ascends and evaporates, or passes off with the appearance of the nascent cumulus. This has long been regarded as a prognostic of fair weather.

The *cirrus* having continued for some time increasing or stationary, usually passes either to the cirro-cumulus or the cirro-stratus, at the same time descending to a lower station in the atmosphere. This modification forms a very beautiful sky, is frequent in summer, and attendant on warm and dry weather. The *cirro-stratus*, when seen in the distance, frequently gives the idea of shoals of fish. It precedes wind and rain, is seen in the intervals of storms, and sometimes alternates with the cirro-cumulus in the same cloud, when the different evolutions form a curious spectacle. A judgment may be formed of the weather likely to ensue, by observing which modification prevails at last.

Howard did not explain the special causes of forms of clouds above described, nor can we point to more than one or two attempts at all sound and scientific to accomplish this. In two papers, however, in the *Philosophical Magazine* (4th ser. xiv. 22; xv. 241), it is shown, by analogical experiments with liquids, that the cirrus arises from the *interfiltration* of masses of air saturated with moisture, and not in equilibrium; the stratus, from mixture or contact of layers of air tranquilly moving on or lying over each other, while the cumulus arises from the violent ascent of columns of air in the atmosphere. The nimbus, rain, or thundercloud appears to be formed in like manner.

Very little is known of the nature of clouds from which slow long-continued rain falls, as it so commonly does in London, but the cloud is probably for the most part stratose.

More particular accounts of the phenomena of the clouds and weather must be sought in works on meteorology, among which by far the most philosophical and reliable, is Sir J. Herschel's Essay on Meteorology (Encyc. Brit. 8th ed.). To this Essay we are indebted for some of the following remarks.

It is more within the province of the chemist to consider the nature of the *matter* of clouds. Meteorologists have generally assumed, as an unsupported dogma, that cloud particles are small vesicles or watery bubbles. Saussure, indeed, is said to have examined these vesicles in the mists of high mountains, and to have found them vary in size from $\frac{1}{4500}$ inch to the $\frac{1}{2780}$ inch, occasionally however attaining the size of a pea. Now although no observer is in general more deservedly trusted than Saussure, his unsupported announcements must not always be adopted as conclusive, and we are quite unaware of any one else having witnessed vesicles of appreciable size floating in the air and forming clouds or mists. It is also stated (*Graham's Elements*, 2nd ed. i. 314), that the vesicles may be observed by a lens of an inch focal length, over the dark surface of hot tea or coffee, mixed with an occasional solid drop, which contrasts with them. Having tried this, we witnessed a white dust of watery particles of uniform size, blowing about over the surface of the coffee, or rising in little wreaths and whirlwinds like dust on a windy day, but we saw no drops appearing solid as contrasted with the rest, and were inclined to consider them all solid particles of about the diameter of $\frac{1}{5000}$ inch. No one has ever suggested how the vesicles are formed, nor is it easy to conceive any possible mode of their formation.

In favour of the vesicular theory, it may be urged that rainbows are at least very seldom produced when the sun shines on cloud or on steam, although a rainbow is exhibited under such circumstances by the minutest rain and by spray from a fountain or waterfall. Sir J. Herschel suggests that the particles may be of an *order of smallness* comparable to the lengths of the light-undulations, which are on an average about $\frac{1}{50000}$ inch long. Hence, he infers, the refractions and reflections of light which cause the rainbow would not take place. (See also Raillard, *Comptes Rendus*, xliii. 906.)

The existence of vesicular vapour of water seems, however, to have been disproved by the microscopic observations of Dr. A. Waller (Phil. Trans. cxxxvii. [1847] p. 23), which later writers have overlooked. Steam being thrown upon a surface of Canada balsam, the particles of water became fixed and were easily examined in the microscope. It was concluded that whenever we are enabled to inspect the minutest particles of water arising from condensed steam or vapours, they consist of minute liquid globules without any appearance of internal cavity.

The suspension of the clouds is in no way mysterious, and arises only from the enormous comparative resistance which the air offers to the motion of a very minute body, as Prof. Stokes has lately shown (Cambridge Phil. Trans. vol. viii. ix.) A globule of water of the diameter of $\frac{1}{1000}$ inch, in falling through the air, would have the maximum velocity of about ·067 inch per second, which is quite inappreciable compared with the ascensional movement of the air, which is generally taking place in all large masses of cloud. The watery particles, or the air, generally both, must then be in motion in every cloud. (See also Phil. Trans. vol. lv. [1765] p. 162.)

No satisfactory reason has ever been given why the clouds only sometimes discharge rain, but it is not difficult to see that if all the particles were of equal size, they would all subside at exactly the same rate, and no collisions could take place. But if a further set of particles were precipitated of a different size they would move at a different rate, and encounter the other particles; many particles would thus coalesce into drops of sufficient size to fall rapidly, and receiving accretions in their passage through the air, reach the surface of the earth as rain. The coalescence of minute globules vastly diminishes their surface as compared with their bulk; it is easy then to understand how electric tension existing on the surface of cloud particles is so intensified when rain falls as to occasion lightning. This theory of the thundercloud was suggested as early as 1752 by Eeles (Phil. Trans. p. 527), and it is repeated in the papers in the *Philosophical Magazine* before referred to.

There are two principal ways in which cloud particles are produced:

1. A gas in changing its volume also changes its temperature, and may thus be unable to sustain in the gaseous state all the aqueous vapour which is diffused through it. Thus, if the air within the receiver of an air-pump be moist, a few strokes of the pump will produce a visible mist. In the atmosphere, by far the largest masses of clouds are thus produced by columns of air rising, and consequently expanding and growing cold as they rise. Fogs, it is also said, may be produced at the surface by sudden changes of barometric pressure.

2. Two masses of moist air of different temperatures will not, when mixed, sustain the whole of the contained vapour in the gaseous state: for the maximum tension of aqueous vapour varies in a higher ratio than the temperature. Hence the mean tension of vapour on mixing, will always be higher than the tension possible at the mean temperature, and vapour will be condensed until the two are equalised. Thus arise the cirrose and stratose forms of cloud, from the mixing of bodies of air under various circumstances.

Gases have but an inappreciable power of conducting heat. A cold surface may indeed condense vapour from the air, as in the formation of dew, but the water condensed will all attach itself to the cold surface, and no cloud-particles will be produced.

Dr. Tyndall having lately proved that gases may radiate heat, it is possible that clouds may be produced in the higher parts of the atmosphere by slow radiation. W. S. J.

CLOVES, OIL OF. *Gewürznelkenöl.*—This oil, obtained by distilling with water the buds and flower-stalks of the clove-tree, *Eugenia caryophyllata*, or *Caryophyllus aromaticus*, L., is a mixture of eugenic acid (*q. v.*) and a hydrocarbon, $C^{10}H^{16}$, isomeric with oil of turpentine. This hydrocarbon passes over with vapour of water, when the crude oil of cloves is distilled with potash-ley. It is highly refractive, has a density of 0·918 at 18° C., and boils at 142°—143°. It is not attacked by alkalis; it absorbs a large quantity of hydrochloric acid, and without forming a crystalline compound (Ettling, Ann. Ch. Pharm. lx. 68). Water distilled from cloves sometimes deposits nacreous scales of eugenin, a substance probably isomeric with eugenic acid.

According to Stenhouse (Ann. Ch. Pharm. xcv. 103), the so-called oil of cinnamon-leaf is likewise a mixture of eugenic acid and a hydrocarbon, $C^{10}H^{16}$. It has a density of 0·862, and boils at 160°—165° C.; it contains also a small quantity of benzoic acid.

CLOVORUBRIN. A resinous body produced by the action of sulphuric acid on oil of cloves.

CLUB MOSS. See Lycopodium.

CLUTHALITE. A mineral related to analcime (p. 210), occurring in flesh-red vitreous crystals in the amygdaloïd of the Kilpatrick Hills. Specific gravity = 2·166. Hardness = 3·5. Opaque or subtranslucent. Fragile. Contains 51·27 SiO^2, 23·56 Al^2O^3, 7·31 Fe^2O^3, 5·13 Na^2O, 1·23 MgO, and 10·55 water = 99·05. (Thomson, *System of Mineralogy*, i. 339.)

CNICIN. *Centaurin.* (Morin, J. Chim. méd. iii. 105; Scribe, Compt. rend. xv. 803).—A bitter substance contained in *Centaurea benedictus* or *Cnicus benedictus* (Morin); also in the leaves of *Centaurea calcitrapa*, and in all bitter plants of the order *Compositæ*, sub-order *Cynarocephalæ* (Scribe). Morin first obtained it in an impure state by treating the alcoholic extract of *Centaurea benedictus* with ether, evaporating, precipitating with sub-acetate of lead, evaporating the filtered liquid after freeing it from lead, and treating the residue with ether and alcohol. It was afterwards obtained by Nativelle and further examined by Scribe.

Cnicin forms white transparent silky needles, inodorous, having a pure bitter taste, and neutral reaction, easily soluble in alcohol and wood-spirit, very little soluble in ether. The alcoholic solution deflects the plane of a polarised ray to the right; $[\alpha] = + 130{\cdot}68°$ (Bouchardat). It is nearly insoluble in cold water, dissolves somewhat more easily in warm water. The solution is decomposed by continued boiling, becoming turbid and afterwards depositing a viscid body like turpentine.

Cnicin gives by analysis 62·9 per cent. carbon, 7·0 hydrogen, and 30·1 oxygen, whence have been deduced the three formulæ $C^{14}H^{18}O^5$, $C^{20}H^{26}O^7$, and $C^{26}H^{34}O^9$. They all agree pretty nearly with the analysis, but as there is no means of determining the atomic weight of cnicin, it is impossible at present to decide between them.

Cnicin submitted to dry distillation gives off vapours and becomes carbonised. Strong sulphuric acid dissolves cnicin with deep blood-red colour, the liquid becoming black when heated. Strong hydrochloric acid is coloured green by it; if heat be applied, the liquid turns brown, and oily drops collect on its surface, solidifying in a resinous mass on cooling.

COAGULUM is a term applied to any viscid or curdy mass separated from a liquid, as cheese from milk, the clot from blood, &c.

COAL. *Houille. Steinkohle.*—The vast masses of fossil fuel which are stored up within the bowels of the earth, and in particular constitute so essential an element of our national prosperity, are undoubtedly the result of complex chemical changes, acting under varying circumstances of temperature, pressure, moisture, &c., either upon vegetable matter growing on the spot, or upon the remains of plants collected by the drift of rivers, &c., into particular localities.

The vegetable origin of coal is beyond doubt, nor can there be any question as to the character of the flora of the carboniferous era, about 500 distinct species, including 250 ferns, having been recognised as belonging to that period.

The discovery of distinct ligneous structure in most kinds of coal appears, however, to be somewhat questionable; and although Bischof and others have entered into interesting and highly valuable speculations as to the precise changes, by virtue of which woody matter may be converted into coal, the microscopic and chemical examination of the substances themselves, do not afford direct *proof* of the accuracy of these conceptions.

The conversion of wood into coal, according to Bischof, may take place in four different ways, viz.:

1. By separation of carbonic acid and carburetted hydrogen.
2. " " " water.
3. " carburetted hydrogen and water.
4. " " " carbonic acid.

(For the formulæ representing these changes we refer the reader to *Bischof's Chemical and Physical Geology*, vol. i. p. 274, *et. seq.*)

"When wood or vegetable matter, then, is buried under circumstances which allow of the extrication of these substances from it, in the course of its decomposition, it *must* become converted into coal; the extreme result of the process being to give us, first anthracite, containing perhaps 94 per cent. of carbon, and finally graphite, which is either pure carbon itself, or that substance mingled with others which are here excluded from consideration, as not being among the elements of wood, and which it may have acquired from external sources during the process of conversion.

"The great quantities of carbonic acid gas (choke-damp), and carburetted hydrogen (fire damp) met with in coal mines, show the fact of the large extrication of these substances, and corroborates, if need were, this explanation. Reservoirs of these gases in a highly compressed state are often found to be pent up in the crevices and cavities of coal beds. Some beds of coal are so saturated with gas, that when they are cut into, it may be heard oozing from every pore of the rock, and the coal is called by the colliers 'singing coal.'" (Beete Jukes, *Manual of Geology.*)

The natural escape of light carburetted hydrogen, marsh-gas or fire-damp (CH^4), which frequently bursts forth in large quantities from the seams of coal or strata of fire-clay which divide them, is the frequent cause of those terrible accidents, of which the Lund Hill Colliery explosion in 1857, and the still more recent one at Burradon, have been the most calamitous upon record.

The sudden issue of gas from a *blower* in the colliery adjacent to that of Lund Hill is thus described. "The fire-clay of the floor of the seam was seen to heave at different points along the face, and presently large fractures were made in it, through which gas was ejected with great violence and with a sound very similar to the issue of steam at a high pressure from a boiler." Subsequent to the explosion at Lund Hill, the pent up gas still issuing within the mine in the higher parts of the workings supported two columns of water 30 feet high, one 10 feet and the other 11½ feet diameter, corresponding to a pressure of about 11 lbs. on the square inch. This gas in exploding renders unfit for respiration 10 times its own bulk of air: hence the "after damp" of the miner, the vitiated atmosphere produced by the explosion, often fatal to those working in other parts of the mine, or to those who descend into the pits without proper precautions, or until ventilation has been sufficiently re-established.

"The subjoined tables, given by Miller, give an idea of the composition of wood and will illustrate the progress of its decay. They also furnish a synoptic view of the composition of some of the principal varieties of coal, in the order of their occurrence in successive geological stages. The proportion of oxygen diminishes rapidly and that of hydrogen more slowly, as the coal passes from lignite towards anthracite, in which form it consists of nearly pure carbon."

Composition of Wood and Coal.

	Oak-wood. Miller.	*Decayed Oak.* Liebig.	*Dartmoor Peat.* Vaux.	*Mexican Asphalt.* Regnault.	*Lignite from Bovey.* Vaux.	*Boghead Coal.* Miller.
Specific gravity .	·81		·849	1·063	1·129	1·196
Coke per cent. .	21·3		29·30	9·0	30·8	30·28
Carbon . . .	50·10	53·47	54·02	78·10	66·31	63·10
Hydrogen . .	6·07	5·19	5·21	9·30	5·63	8·91
Nitrogen . .			2·30		0·56	7·25
Oxygen . . .	43·68	41·37	28·17	9·80	22·86	
Sulphur . . .			·56		2·36	·96
Ash . . .	·15		9·73	2·80	2·27	19·78

Composition of Coal.

	Lesmahagow Parrot Coal. Miller.	*Wigan Cannel.* Vaux.	*Caking Coal Newcastle.* Richardson.	*10 yard Wolverhampton.* Vaux.	*Newport Steam.* Miller.	*S. Wales Anthracite.* Vaux.
Specific gravity .	1·251	1·276	1·280	1·278	1·309	1·392
Coke per cent. .	43·3	60·36		59·21	75·10	92·10
Carbon . . .	73·44	80·07	86·75	78·57	81·47	90·39
Hydrogen . .	7·62	5·52	5·24	5·29	4·97	3·28
Nitrogen . .	11·761	2·12	6·61	1·84	1·63	0·83
Oxygen . . .		8·08		12·88	5·28	2·98
Sulphur . . .	1·145	1·50		·39	1·10	0·91
Ash . . .	6·034	2·70	1·40	1·08	5·51	1·61

The composition of coals varies largely, not only in respect of the relative proportions of carbon, hydrogen, oxygen and nitrogen which they contain, but also of the amount of extraneous matters which constitute the impurities of fuel. These consist of a variable amount of mineral matters which remain after combustion of the coal, as ash or "clinker."

The percentage of ash ranges from about 1 to 30 or 35, and in some coals, which are considered too poor to be brought to market, to even more than this quantity.

It consists chiefly of silicate of alumina, with variable amounts of oxide of iron. Vaux found also in many coals traces of lead and copper.

"We have in nature every gradation, from pure coal into a mere carbonaceous (commonly called bituminous) shale or 'batt' which often contains enough inflammable matter to give out flame and support combustion for a time when burnt with better coals, but soon passes into a lump of ash, unaltered in form and not retaining heat longer than a brickbat would under similar circumstances." Accordingly, the composition of the ash of coals closely resembles that of the batts, shales, or fire-clays which usually occur, either as strata above or below the coal, or in their "partings" between the several layers of the coal itself.

The following table exhibits the amount and composition of the ashes of several coals, as compared with that of fire-clays and "batts":

Composition of Coal-ash.

	Newcastle coal after deducting Suphuric acid. Taylor.	Porous Coal from Zwickau. Kremers.	Compact Coal from Zwickau. Kremers.	Average of five samples. Welsh. Phillips.	Average of five samples. Scotch. Phillips.	Blue Shale clay. Taylor.	Newcastle Fireclay. Richardson.	American Anthracite. Fawn.	Ash of Bituminous Shale, Bilston, Staffordshire. Wills.
Silica . .	62·44	60·23	45·13	42·67	49 63	58·99	57·06	54·50	60·31
Alumina .	31·22	31·63	22·47	43·56	38·21	26·19	35·02	34·45	29·85
Sesquioxide iron . .	2·26	6·26	25·83		. .		5·17	7·50	3·14
Lime .	·75	1·08	2·80	6·65	3·18	Fe^{2}O.10·25	1·63	2·25	2·19
Magnesia .	·85	·35	·52	1 08	1·41	67	1·73	1·30	1·83
Potash .	2·48	. .	. .	. .	. .	1·54	. .	. .	2·12
Soda . .	. .	. .	·24	. .	. .	2·34	. .	. .	
Sulphuric acid (anhydrous) .	. .	. .	. .	4·46	6·26	. .	. .	. .	0·69
Sulphate of Calcium .	. .	·24	2·27						
Phosphoric acid (anhydrous) .	. .	. .	. .	·66	1·03	. .	. .	. .	traces.
Percentage of Ash .	1·36	1·74	1·89	8·15	. .	. .	. .	. .	Chlorine 0·06

Muspratt states that the ash of lignite varies from 1 to 60 per cent., averaging about 5, and that of bituminous coal 1 to 2 per cent. In addition to these substances, the mineral matter of coal contains a small but variable quantity of sulphur, not accounted for in the above analyses, but constituting a most important element as regards the value of fuel for domestic and technical uses. This remark applies more especially to the value of coals for metallurgical purposes, particularly for employment in the blast-furnace; the ironmaster has learned to eschew such samples of ironstone as contain any considerable percentage of sulphur and phosphoric acid; but this precaution is wholly ineffectual, unless a like care be exercised in the selection of the fuel and fluxes which are to be introduced into the blast-furnace with the ore.

The presence of sulphur is equally detrimental in the manufacture of gas, some portion of it being always eliminated as sulphuretted hydrogen and bisulphide of carbon, the complete removal of which is a matter at once of great difficulty and of the highest necessity, while the frequent cases of spontaneous combustion of coals in the hold of vessels is probably due, in some measure, to the oxidation of the pyrites which they contain under the influence of a moist atmosphere.

A minor evil is the evolution, during combustion, of sulphurous acid, a gas which is not only noxious and hurtful to human life, but destructive to boilers, locomotive tubes, and so forth.

Some of the lower seams of the South Staffordshire coal beds, otherwise available as good fuel, are unused, because they contain an amount of sulphur which renders it impossible to bear the smell which they exhale during combustion; whence their local name of *stinking coal*.

The mean percentage of sulphur found in the government investigation, under Playfair and De la Beche, was as below:

Samples.	Coals.	Mean.
37	Welsh	1·42
8	Derbyshire	1·01
28	Lancashire	1·42
17	Newcastle	0·94
8	Scotland	1·45

The following are other determinations of sulphur in coals:—

	Mean.
4 samples from North Wales, Ruabon	·79
Lignite from Bovey (Vaux)	2·36
Boghead (Miller)	0·96
Wigan cannel (Vaux)	1·50
10 yard Wolverhampton	0·39
„ bottom	2·57
Newport steam coal (Miller)	1·10
Anthracite, South Wales (Vaux)	·91

"The frequent occurrence of iron pyrites in coal shows that its formation at the cost of organic remains is a very frequent phenomenon. This formation of iron pyrites can only be explained by the presence of sulphates; and so far as it goes on in the sea, only by the decomposition of sulphate of calcium.

The minor varieties of coal are almost infinite in number, and it is said that full a hundred different kinds are sent into the London market. The following appears to be as satisfactory a classification of the more important kinds as is possible, together with an indication of their characteristic differences, and of the localities whence they are obtained:—

1. LIGNITE or BROWN COAL generally retains in some degree its lamellar and woody structure. Yields a powdery coke in the form of the original lumps. Brittle, burns readily, but often contains from 30 to 40 per cent. water.

Occurs in England chiefly at Bovey Heathfield, in Devonshire, where it has long been used as fuel in the local potteries; the supply is now, however, falling off. Its other chief localities are Westphalia, the Hessian States, Lower Austria, Russia, Spain, Portugal, Italy, the Upper Missouri Valley, New Brunswick (impregnated with copper), Greenland, China, and the Burmese Empire, and in Central America in the province of Panama.

2. BITUMINOUS or CAKING COALS.—The most extensively diffused and valuable of English coals. These are of various shades of brown and black, emit much gas on heating, and hence are prized as "gas-coals;" they leave a coke more or less lustrous and fused, or *caked* together. Their fracture is generally uneven and their lustre resinous. The coals of this class are subdivided into:

Caking Coal, which splinters on heating, but the fragments then fuse together into a semi-pasty mass. Its chief sources are the Newcastle and Wigan districts, along the banks of the Tyne and Wear, and the north of the Tees.

Cherry Coal or *Soft Coal*.—Lustre very bright. Does not fuse. Ignites well and burns rapidly. Occurs in Glasgow, Staffordshire, Derbyshire, Nottingham, Lancashire, &c.

Splint, Rough or *Hard Coal.*—Black, and of glistening fracture. Does not ignite readily, but burns up to a clear hot fire, constituting a good house coal. Occurs in the Glasgow field, in Shropshire, Leicestershire, Warwickshire, Derbyshire, and at Nottingham, and constitutes in particular the bulk of the great coalfields of North and South Staffordshire.

Cannel Coal; Parrot coal of Scotland.—Of dense, compact, and even fracture, conchoïdal in every direction. Takes a polish like jet. Splinters in the fire and burns clearly and brightly. The chief localities in Great Britain are Wigan, and other parts of Lancashire, West Glasgow, and in smaller quantities at Coventry. It is found also in Kentucky.

The various kinds of bituminous coal constitute also the bulk of the immense coalfields of North America, compared with which the most extensive fields of the Old World are insignificant. These are the Alleghany or Appalachian field, and those of Pennsylvania, Illinois, New Brunswick, and Nova Scotia. In South America they occur in the province of Chili. They compose also the south side of the South Wales basin; are found in Connaught and Ulster, and on the European continent in Belgium, France, Prussia, Sweden, Russia, and Spain. Finally, the great coal range of New South Wales is supposed to belong to this class.

4. ANTHRACITE. STONE-COAL or CULM.—The densest, hardest, and most lustrous of all varieties. Burns with very little flame or smoke, but gives great heat. Contains very little volatile matter. Splinters when heated, and ignites with difficulty. Colour deep black, fracture lamellar, parallel to the bed of the deposit, conchoïdal in the cross fracture. Applied successfully to smelting, and much valued as a steam coal in the navy. Its most extensive deposit occurs over vast tracts of North America, chiefly in Pennsylvania. It constitutes also a large portion of the yield of the north-west portion of the South Wales coalfield. A further deposit occurs over a tract of about 12½ miles in Devonshire, in the neighbourhood of Barnstaple Bay and Bideford. Its other situations are Leinster and Munster in Ireland, and some districts of France, Sweden, and Portugal.

5. STEAM COAL approaches nearly to anthracite. It does not crumble into small pieces under friction, and is hence well adapted for stowage. It also emits little smoke, a point of great importance in naval warfare, where the smoke of ordinary coals would reveal the position of vessels to a distant enemy. Its chief locality is the north-west of the South Wales basin and the north of the Tyne and Blyth district.

In addition to the above-named varieties, we must mention the remarkable deposit of Bathgate, near Edinburgh, commonly known as the "Torbane hill mineral or Boghead cannel coal," respecting which a curious lawsuit arose upon the question whether or not the substance was to be considered as "coal." It is of a dull brown colour in the upper part, and black in the lower part of the seam, and of low specific gravity. It contains about 20 per cent. of aluminous ash, which remains after ignition in the form of the original lump, retaining 6 to 10 per cent of carbon. About 70 per cent., therefore, consists of volatile matter, whence the great value of the mineral for two purposes; 1st for gas making; 2nd for distillation, by Young's process, in close vessels at a low temperature, whereby a large number of liquid hydrocarbons of various densities and boiling points are obtained, fit respectively for illuminating and lubricating purposes, together with paraffin and other solid products.

The analyses already given fairly represent the ordinary composition of the several classes of coals.

Valuation of Coal.—A ready method of accurately estimating the general value of coal as fuel is yet a desideratum. Its elementary analysis affords the means of calculating its theoretical heating power; but it is found in practice that the amount of work indicated by this result can never be obtained, and further that the condition of mechanical division, draught of furnaces, and many other extraneous circumstances affect the result so largely, that the actual work obtained seldom bears any palpable relation to the theoretical indication.

The weight of water in pounds raised *one degree* in temperature by the combustion of 1 cubic inch of each of a large number of combustible substances, and also by such a weight of each as combines with 1 cubic inch of oxygen, has been determined by the direct experiments of Lavoisier, Laplace, Despretz, Dulong, Rumford, Regnault, Andrews, and others, the general principle of their methods consisting in the use of an apparatus wherein the entire heat of combustion was absorbed by a known weight of water, the whole arrangement being protected from the influence of external changes of temperature, and the increase of temperature of the water being known by the simultaneous indication of several delicate thermometers suspended in it. (See HEAT.)

The method of Berthier, though only approximative, affords useful indications when applied, with certain precautions, to various samples of the same class of coal or from the same mine.

It is based upon the reduction of oxide of lead by the carbon and hydrogen of the fuel, in fact the combustion of the coal at the expense of the oxygen of litharge, the weight of metal produced indicating the amount of oxygen expended, whence the heating power may be calculated. It is found that 1 pt. of pure carbon produces 34·5 of metallic lead; hence if a sample of fuel produces 25, the heating power is $\frac{25}{34 \cdot 5}$ of that of carbon, or assuming that 1 lb. of carbon raises 7900 lbs. of water 1°, 1 lb. of the sample of coal is capable of raising 5724 lbs. of water by 1°.

Various tables have been given by Berthier and other experimenters, of results obtained in this manner, the following being some of the most useful figures: —

Coking Dowlais coal	produces	31·8 lbs. lead
Glamorgan	"	31·2 "
Newcastle	"	30·9 "
Wigan cannel	"	28·3 "
Cherry coal, Derbyshire	"	27·2 "
Glasgow cannel	"	24·9 "
Durham	"	31·6 "
Pennsylvanian anthracite	"	30·5 "

By a comparison of the result of any experiment with these standard figures, a tolerably fair estimate may be made of the specific value of any sample.

The method of operating consists simply in mixing a known weight of the finely powdered fuel with about forty times its weight of pure litharge, and exposing the mixture to a gentle heat in a large crucible finally raised to a clear red heat. The pot is removed, struck on the floor to assist the settling of the metal, and broken when cold. The button is cleaned and weighed. The accuracy of the result depends greatly upon the relative proportion of hydrogen and oxygen: when they are in the proportion necessary to form water, the result is tolerably correct; but it is evident that any excess of hydrogen over and above this proportion introduces an error, inasmuch as its heat equivalent is calculated as if it were carbon, while in truth it is about four times as great. The results of the British Admiralty investigation, by De la Beche and Playfair, exhibit a variation often "amounting even to a virtual contradiction" of the simultaneous results of direct combustion.

Other experimenters have found difficulty in obtaining constant results by Berthier's method, but Mitchell has found that the difficulty may be obviated by substituting ordinary carbonate of lead for the litharge.

The best practical method of valuing fuel consists in employing an apparatus similar to those used by Andrews and other chemists in the determination of the actual heating power of carbon, hydrogen, &c., or of a miniature furnace to which a known volume of air is supplied, with arrangements, such as readily suggest themselves, for the complete utilisation of the heat evolved. It is to be remembered that the real value of all such results is simply relative.

The imperfect character of most boiler arrangements and the large quantity of coal which passes into the ash-pit unconsumed, together with the irregular supply of draught and the amount of heat absorbed by the great excess of cold air, result practically in an enormous loss of heating power, to an extent which, even under the most careful management, is widely variable. Thus, the results obtained in the American and British Admiralty experiments exhibit grave discrepancies. In the case of the latter investigation, a Cornish boiler only 12 feet long was employed, and "even from the smallness of the boiler employed, the results fell short by 20 per cent. of the maximum amount of work which the same fuels could perform when applied to larger boilers constructed and set on the same principle. The inquiry is rendered less efficient from another cause, viz. the want of a thorough control and measurement of the air passing through the furnace."

We have referred to the injurious properties of *sulphur* as an ingredient in coals, and to its average quantity in various classes of fuel. Its amount may be estimated by fusing in a large silver capsule a few pieces of caustic potash and ¼ of its weight of nitrate of potash and a few drops of water. After cooling, the finely powdered coal is added, and the whole re-fused till white. The mass is dissolved in hydrochloric acid, and the sulphuric acid produced is estimated by precipitation with chloride of barium. It is always necessary at the same time to estimate the quantity of sulphuric acid present in the ash of the coal, and to deduct this from the amount obtained as above, in order to obtain the quantity due to the oxidation of the sulphur only.

Deflagration with 2 pts. nitre and 10 of chloride of sodium may also be employed, but the greatest care is necessary to control the action.

The importance, in addition to a knowledge of the chemical character of a fuel, of a consideration of its *mechanical condition*, is amply exhibited by the fact acknowledged in both the government series of experiments, that it was a *sine quâ non* that the toughness of coals must be such, for naval use, as to resist, without crumbling, the constant friction in the ship's hold, at the same time that its fracture must be such that it packs into the smallest possible space. In this respect, coals of equal heating power vary 20 per cent. at least. "This factor, which is of extreme importance in steam-navigation, becomes reduced the more the cleavage of the coal or the shape of the fuel approaches the form of a cube. In order to attain, at least, a relative idea of the waste occasioned by transport, *i. e.* of the attrition of the individual pieces of coal against each other, and conversion of unbroken coal into dust unfit for use, which is occasioned by the motion of the vessel, the various specimens were rotated in a drum for the same length of time, and the dust thus produced separated and weighed."

The subjoined table shows some of the results of the British investigation as regards:

1. Number of lbs. of water at 100° C. converted into steam by 1 lb. of fuel.
2. Ditto, after deducting portions of coke contained in the ash.
3. Theoretical evaporative power in lbs. of water of 100° C. evaporated by 1 lb. of fuel calculated from litharge test.
4. Weight of coal per cubic foot of stowage in lbs.
5. Ditto, per solid cubic foot, deduced from specific gravity.
6. Percentage loss by equal amount of attrition

Kind of Fuel.	1.	2.	3.	4.	5.	6.
WELSH:—						
Jones and Co's Anthracite	9·46	9·70	13·84	58·25	85·79	68·5
Ward's Fiery Vein	9·40	10·60	16·40	57·43	83·85	46·5
Graigola	9·35	9·66	16·72	60·17	81·11	49·3
Duffryn	10·14	11·80	15·64	53·22	82·72	56·2
Ponty Pool	7·47	8·04	14·31	55·70	82·35	57·5
Ebbw Vale	10·21	10·64	16·68	53·30	78·81	45·0
Bedwas.	9·79	9·99	14·70	50·50	82·60	54·0
SCOTCH:—						
Dalkeith Jewel	7·08	7·10	13·77	49·80	79·67	85·7
Wallsend Elgin	8·46	8·67	15·15	54·60	78·61	64·0
Fordel Splint	7·56	7·69	15·12	55·00	78·61	63·0
Grangemouth	7·40	7·91	14·85	54·25	80·48	69·7
ENGLISH:—						
Broomhill	7·30	7·66	13·20	52·50	77·99	65·7
Park End, Sydney	8·52	8·98		54·44	80·05	55·0
IRISH:—						
Slieverdagh	9·85	10·49	16·21	62·80	99·57	74·0
Mean of three patent fuels	9·27	9·66	15·44	66·48	70·66	

For further information on coal, see *Ure's Dictionary of Arts, Manufactures and Mines*, i. 696; also *Ronalds and Richardson's Chemical Technology*, 2nd ed. i. [1] 28; i. [2] 761; *Percy's Metallurgy*, i. 78—106. A. W. W.

COAL-GAS. The gas produced by the destructive distillation of pit-coal at regulated temperatures.

The apparatus used in the manufacture of coal-gas on the great scale consists essentially of a system of closed retorts of fireclay or cast-iron, the exit pipes from which communicate with a *hydraulic main*, in which the crude gas deposits part of its tar and ammoniacal products. It passes thence into a series of condensing pipes, wherein it is exposed to the action of a large refrigerating surface, and deposits the greater part of its tar and ammonia-liquor, the last portions being removed in its passage through another series of vessels of various forms and modifications, in which the gas is *scrubbed*, by being obliged to force its way through breese, stones, or other materials which serve to comminute it and bring it into thorough contact with a stream of water which continually percolates the vessel. It is then deprived of its carbonic acid and sulphuretted hydrogen in lime purifiers, and finally is drawn by exhausting apparatus into the gas-holders, passing on its way through the station-meter and other beautiful and delicate apparatus, whereby the pressure and amount of gas which passes into the town are regulated and registered. (See the article COAL-GAS in *Ure's Dictionary of Arts, Manufactures and Mines.*)

The following analysis by Bunsen and Roscoe exhibits the composition of Manchester coal-gas prepared from Cannel coal:

Hydrogen	45·58
Marsh-gas	34·90
Carbonic oxide	6·64
Olefiant gas or ethylene	4·08
Tetrylene	2·38
Sulphuretted hydrogen	0·29
Nitrogen	2·46
Carbonic acid	3·67
	100·00

In addition to these constituents, there are frequently present traces of ammonia, vapour of sulphide of carbon, cyanogen, and oxygen.

The composition above given, represents that of a first-rate sample of gas; but the relative proportion of the several ingredients depends both upon the quality of coal used, upon the temperature of the retorts, and the time during which the distillation is continued. It is to the olefiant gas and other heavy hydrocarbons present in comparatively small quantities, that the illuminating power of gas is chiefly due; the maintenance of a full proportion of this gas is therefore of the utmost importance. The following table shows the quality of gas from 1120 lbs. of common coal at the Clifton gas-works, Manchester, at different periods of distillation:

Hours from commencement.	100 measures purified gas contain			100 measures of purified gas consume
	Olefiant gas.	Nitrogen.	Other inferior gases.	Oxygen.
1	10	0	90	164
3	9	0	91	168
5	6	0	94	132
7	5	15	80	120
9	2	9	89	112
11	0	15	85	90

Hence, two things should especially be avoided in the manufacture of gas, viz. too low a heat and a too long continuation of the distillatory process. The effect of too low a heat is a great diminution of the gaseous products, the chief result of the distillation being the production of tar. The effect of continuing the distillation too long, is that gases of very feeble illuminating power are evolved, together with nitrogen, which, when once mingled with the combustible gas, cannot be removed by any known method, and must seriously impair its illuminating power.

The following table by Hughes gives an idea of the relative and absolute yield of different kinds of coal under practical management:

Name of Coal.	Cubic feet of Gas per ton.	Specific Gravity of Gas.	Weight of Gas in lbs. per ton of Coal.
Newcastle, average of 3 samp.	11,492	·452	398 Hedley.
„ „ 10 „	11,336	·416	362 Clegg.
Wigan cannel . . .	9,500	·490	357 Fyfe.
„ . . .	9,408	·478	344 Wright.
Scotch Parrot . . .	9,500	·640	466 „
Lesmahago cannel . .	11,312	·737	638 Hedley.
Boghead cannel . . .	15,000	·752	866 Evans.
Ince Hall cannel . .	11,400	·528	461 „
Derbyshire	9,400	·424	308 Wright.
„ soft, aver. of 3 samp.	7,166	·466	256 Parliamentary return.
Neath, South Wales . .	11,200	·468	401 Hedley
Westbromwich, parliamentary return of Birmingham gas company . . .	6,500	·453	226
Staffordshire, average of 4 samples	10,467	·376	302 Clegg.

Modes of estimating Luminiferous Value.

The gas manufacturer relies much as an indication of the purity of his gas, upon its specific gravity, which he commonly takes approximately by means of a balloon, containing when full 1000 cubic inches, and gauged by a ring which fits its largest diameter when full. Attached to the balloon is a car, into which as many grains are put as balance the balloon. This result, although not scientifically accurate, gives, after correction for temperature, barometer, &c., an indication of sufficient practical value, but of course vitiated by the presence of any large amount of carbonic acid.

The comparison of gases by the photometer is a test preferred by many gas-engineers to all others. It consists of the comparison either of shadows, or of transmitted light passing through a semi-transparent disc of paper with reflected light striking on an opaque portion, in juxtaposition to the transparent portion. When the light is so adjusted that the shadows are precisely similar, or that the light reflected and that transmitted by the disc are equal, then the lights are to each other in the ratio of the squares of their distance from the disc or screen.

The only chemical test upon which the practical gas maker commonly relies, is the amount of absorption which takes place upon introducing into a known volume of gas a bubble of chlorine or a drop of bromine, the principal hydrocarbons to which gas owes its luminiferous value being condensed by these reagents into oily compounds. These methods are, however, of the roughest kind.

An accurate result may, however, be obtained by substituting for chlorine or bromine a fragment of coke saturated with Nordhausen sulphuric acid, the experiment being made over mercury and the absorption being allowed to go on for two or three hours Subsequently the sulphurous acid produced in this action is removed by a ball of binoxide of manganese, and finally aqueous vapour is removed by a ball of caustic potash. The quantity of carbonic acid being also determined, the difference between the two experiments gives the amount of luminiferous hydrocarbons accurately. The value of these, being in proportion to the carbon they contain, is ascertained by exploding portions of gas before and after removal of the hydrocarbons with excess of oxygen, and comparison of the amount of carbonic acid produced in each case respectively. The difference is the amount due to the carbon of the luminiferous constituents. (For details of the mode of analysis of such a mixture, we refer to *Miller's Chemistry*, ii. 661, to *Regnault's Cours Élémentaire*, iv. 73, to *Clegg's Treatise on Coal-gas*, and more particularly, for the most recent and accurate methods of operation, to *Bunsen's Gasometry*, p. 107, to the article ANALYSIS (VOLUMETRIC) OF GASES, in this Dictionary, and to the article COAL-GAS in the new edition of *Ure's Dictionary of Arts, Manufactures and Mines.*)

The Rev. W. R. Bowditch proposes to determine the relative illuminating power of coal-gas, in other words, the proportion of ethylene, propylene, and other heavy hydrocarbons contained in it, by the intensity of the red colour which they impart to woody fibre moistened with sulphuric acid. When rich coal-gas, giving the light of 20 to 25 sperm candles from consumption of 5 ft. per hour, is slowly passed through clean deal sawdust, well moistened with pure sulphuric acid diluted with five or six volumes of water, so that it may not blacken the sawdust, that substance instantly acquires a beautiful pink colour, which gradually deepens to a dark mahogany; with a poor gas, which gives the light of only ten or twelve candles at the same rate of consumption, the coloration is faint at first and deepens very slowly. The differences of coloration are so considerable and constant that they may perhaps be used as a means of determining the illuminating value of the gas. By using a standard acid, the same kind of sawdust, a uniform volume of gas, and the same sized U-tubes, notation of time and depth of colour would give a close approximation to the light-giving value. (Proc. Roy. Soc. xi. 25.)

In addition to the constituents estimated by these operations, it is frequently important to determine sulphuretted hydrogen and bisulphide of carbon. Their presence is well detected by the simple and useful apparatus of Wright, consisting of an arrangement for condensing the products of combustion from a gas-jet, and testing the condensed liquid for sulphuric acid.

Their *amount* may be determined by passing a known volume of gas through, 1st, a solution of caustic potash in water, and, 2nd, a solution of the same reagent in alcohol. The former absorbs sulphuretted hydrogen; the latter the sulphide of carbon, which it converts into xanthate of potassium, which is in turn decomposed by boiling. Dilute solution of nitrate or acetate of lead being added, sulphide of lead is precipitated, and its amount is judged of by comparison of the shade of colour produced in the liquid with a solution containing a known quantity of lead precipitated in the like form.

Another method of detecting sulphide of carbon in coal-gas, is to pass it through an ethereal solution of *triethylphosphine*, which forms with sulphide of carbon a compound crystallising in splendid ruby-red prisms (**Hofmann**, Chem. Soc. Qu. J. xiii. 87). This is a much more delicate test than the preceding. Hofmann found that, on passing a current of coal-gas through a solution of four or five drops of triethylphosphine in ether contained in a bulb-apparatus, a distinct red coloration was produced after 0·2 of a cubic foot of gas had passed through the liquid; and after 0·8 of a cubic foot had passed, the whole of the ether had evaporated, and the inner surface of the bulb-apparatus was lined with a beautiful net-work of the ruby crystals.

Lastly, the sulphide of carbon may be easily detected by a method which likewise serves for its removal. For this method we are indebted to the Rev. **W. R. Bowditch** (*loc. cit.*) It consists in decomposing the sulphide of carbon with hydrogen, thereby converting it into sulphide of hydrogen, which is easily detected and removed by the usual methods. When a mixture of hydrogen and vapour of sulphide of carbon is passed through a tube filled with slaked lime or clay, which has been dried between 400° and 500° Fahr., and is kept between 400° and 600° during the passage of the gaseous mixture, the sulphide of carbon is completely decomposed, the lime or clay is blackened by a deposit of carbon, and sulphur sublimes in the exit-tube, while sulphide of hydrogen passes through, and may be detected by acetate of lead. The same effect is produced when coal-gas containing sulphide of carbon is passed over heated lime or clay, the free hydrogen in the gas then decomposing the sulphide of carbon in the manner just described. This method may be applied on the large scale to the purification of coal-gas from sulphide of carbon, the sulphuretted hydrogen resulting from the decomposition being afterwards removed by slaked lime in the ordinary way. Passing the gas over clay likewise decomposes other volatile sulphur-compounds which are not removed by the ordinary mode of purification with lime. These compounds, including sulphide of carbon, have long been regarded as the most troublesome impurities of coal-gas. The sulphur which is evolved from the coal as sulphuretted hydrogen, is easily removed by slaked lime; indeed, the London coal-gas rarely, if ever, exhibits the slightest trace of this compound. But it always contains sulphide of carbon or some of the other volatile sulphur-compounds just mentioned, the proportion of sulphur contained in it varying, according to Hofmann (*loc. cit.*), from 6·68 to 10·33 grains in 100 cubic feet. Now the sulphur in burning produces sulphurous acid, which, besides being offensive to the senses, is very destructive to art-decorations, bindings of books, &c. The removal of these sulphur-compounds will, therefore, do away with the greatest existing objection to the use of gas in dwelling houses.

The use of clay as a purifier of coal-gas is likewise attended with other advantages, as it absorbs ammonia and other nitrogen-compounds which diminish the light-giving power of the gas. This effect is especially conspicuous when the gas given off towards the end of the distillation (p. 1036), is submitted to the action of the clay.

Clay which has become charged with the impurities from coal-gas, may afterwards be used as a manure.

Secondary Products obtained in the manufacture of Coal-gas.

After a charge of coal has been worked off to the extent considered most desirable, the man-lids are removed from the retorts, and the residual coke raked out into barrows, wheeled away and quenched with a jet of water. Its appearance and uses, as fuel for locomotives, in the blast furnace, and in a vast number of technical operations, are too well known to need description, nor does space allow us to go into details of the numerous processes which have been employed, with more or less success, for the economical preparation and purification of coke.

The liquids condensed during the passage of the gas through the hydraulic mains and condensers, are of a very complex character. They consist essentially of two portions, the one watery and the other tarry, crude coal-tar varying in density between 1120 and 1150, the lightest portions containing the largest proportion of liquid oils.

The basic substances contained in coal-tar include ammonia, aniline, picoline, chinoline, pyridine, toluidine, and others of less importance.

The acids include acetic in minute quantities, rosolic, brunolic, &c., but principally phenic or carbolic acid. The neutral portions contain benzene, toluene, cumene, cymene (liquids); naphthalene, paranaphthalene or anthracene, chrysene, and pyrene (solids).

The commercial distillation of coal-tar is performed in large retorts, holding from 200 to 500 gallons. The first products are gaseous; next passes water charged with ammoniacal salts, and contaminated with black oily matter.

The proportion of oil continues to increase, while that of watery products diminishes. Finally, after from 5 to 10 per cent. of the whole has passed in the form of "light oil," the product becomes heavier than water, and is collected apart as "kreasote oil," or "dead oil" used extensively for the pickling or antiseptic preparation of timber, and for burning into lamp-black. Naphthalene and other solid products now become abundant and the oil becomes pasty. Finally, the residue in the retort is run off while hot, and on cooling becomes hard and brittle, constituting *asphalt*, a product used in the manufacture of coarse varnishes, and on a vastly larger scale in laying down railway and other bridges, as a means of protecting their masonry from the infiltration of water.

The heavy oil contains a variety of hydrocarbons of high boiling point, together with carbolic acid, to which latter it probably owes its antiseptic qualities.

The light oils obtained in the above process are rectified, whereby a further portion of heavy oils is separated and crude *naphtha* obtained. This is agitated with sulphuric acid, and the supernatant liquid, upon careful rectification, yields the "highly rectified naphtha" or "benzole" of commerce, consisting of a complex mixture of at least five oils boiling at from 149° to 392° F., and of specific gravity ·860 to ·890.

The watery liquids deposited in the condenser during the manufacture of gas, are devoted to the production of sulphate and chloride of ammonium. They are usually removed from the gas-works in flats or canal boats of known capacity, under contracts commonly taken at so much per 10,000 gallons.

The manufacture of chloride of ammonium direct from the liquors, is conducted on a large scale in Liverpool, and consists essentially in saturating with hydrochloric acid, concentrating the liquors, crystallising and subsequently subliming the crystals. A far larger portion, however, of the crude gas-liquor is consumed in the manufacture of sulphate of ammonium, by processes which consist essentially of distillation, with addition of lime, to decompose ammoniacal salts, and condensation of the vapour in sulphuric acid, concentration and crystallisation of the solution after saturation has been effected. Sulphate of ammonium is employed in large quantities in the manufacture of artificial manures.

The above are the chief products of distillation of coal at high temperatures, while those at regulated low temperatures are far different. Under the latter conditions, the gaseous products are reduced to their minimum, while the quantity of liquid and solid hydrocarbons is proportionately increased.

The Boghead Cannel of Bathgate, near Edinburgh, is extensively submitted to the process of slow destructive distillation, under the patent of Young, while successful efforts have lately been made by Mr. Blackwell, of Dudley, to turn to account the vast heaps of somewhat bituminiferous shales or "batts" ejected from the coal mines of Staffordshire.

To this subject we cannot further refer than to remark that for practical purposes the products may be separated into three portions.

1. Remains liquid at all ordinary temperatures and forms, after proper purification, a valuable burning oil, known as "photogen."—2. Deposits crystals of solid hydrocarbons at very low temperatures; used extensively for lubricating machinery and known as "paraffin oil."—3. Solid or semi-solid products, which when freed from the oils which contaminate them by pressure, &c. consist chiefly of paraffin (*q. v.*) and may be employed alone or mixed with tallow, stearin, &c. in the manufacture of candles.

A. W. W.

COBALT. *Kobalt, Cobaltum.—Symbol*, Co. *Atomic Weight*, 58·8.—The use of cobalt for imparting a blue colour to glass, appears to have been known to the Greeks and Romans, though most of their blue glasses were coloured with copper. Some of the pigments used by the ancient Greeks likewise contained cobalt. The use of cobalt for the preparation of smalt was introduced about the middle of the sixteenth century. The metal, in an impure state, was first extracted by Brandt in 1733.

Cobalt is not a very abundant metal. It occurs as an arsenide, called *tin-white cobalt* or *smaltine*; as sulpharsenate, or *cobalt-glance*; as arsenate, or *cobalt-bloom*; as sulphate and as *black earthy cobalt*, which is a compound of protoxide of cobalt with peroxide of manganese. It also occurs in small quantity in other minerals—as in selenide of lead, cerite, and Flemish coal. In the metallic state, it occurs only in meteorites, many of which contain from 0·1 to 1 per cent. of it, associated with iron and nickel.

Preparation.—Cobalt is extracted chiefly from smaltine and cobalt-glance, or from the impure arsenate obtained by roasting these ores. The roasting has the effect of driving off a considerable portion of the arsenic, which escapes as arsenious oxide, and is condensed in the manner described under Arsenic (i. 365). The roasted product consists essentially of basic arsenite, arsenate and sulphate of cobalt, together with iron, nickel, and in smaller quantity bismuth, tin, copper, and manganese. When prepared on the large scale, it is mixed with twice its weight of siliceous sand, and sent into the market under the name of *zaffre*, which is used for giving a blue colour to glass, enamels, and pottery glaze.

The preparation of a pure oxide of cobalt from the native minerals or the roasted ore, is effected by one of the following processes:

1. Cobalt or smaltine is dissolved in nitric acid, or in dilute sulphuric or hydrochloric acid, to which a little nitric acid is added,—or the roasted ore or earthy cobalt is dissolved in sulphuric or hydrochloric acid alone; the filtered solution is

evaporated nearly to dryness, a large quantity of arsenious acid then separating out; and the liquid is largely diluted, separated from the arsenious acid, and treated with sulphuretted hydrogen as long as the sulphides of arsenic, copper, and bismuth (together with tin) continue to be precipitated. The solution is then filtered, and heated till the excess of sulphuretted hydrogen is expelled and the protoxide of iron converted into sesquioxide; carbonate of sodium is then added in excess, while the liquor is hot, to precipitate the nickel and cobalt in the form of carbonates, and the iron as sesquioxide. The precipitate is then well washed and digested with excess of aqueous oxalic acid; the soluble ferric oxalate is separated by filtration from the oxalates of nickel and cobalt, which are insoluble even in excess of oxalic acid; and the latter salts are triturated with dilute ammonia (it should be strong ammonia according to Stromeyer) and dissolved in excess of the ammonia, by agitation and gentle heating in a close vessel. The filtered solution, after exposure to the air for several days, deposits the oxide of nickel in combination with oxalic acid and a small quantity of ammonia, while pure oxalate of cobalt remains in solution. (The oxalate of nickel separated as above may be freed from the small quantity of cobalt-salt which falls down with it, by washing with water, re-dissolving in ammonia, exposing the liquid to the air, and separating the solution which contains the cobalt from the nickel precipitate, the purity of which increases at each repetition of the process.) The residue obtained by evaporating the ammoniacal solution of the oxalate, yields sesquioxide of cobalt when ignited in the air, and metallic cobalt if ignited out of contact of air. (Laugier.)

2. To avoid the tedious passing of sulphuretted hydrogen through the liquid, the arsenic acid may be precipitated by first mixing the dilute solution with a ferric salt, and then adding carbonate of potassium in small successive portions and with constant agitation, as long as the precipitate continues to exhibit a white or brownish colour (arsenate of ferric oxide); till, in short, a filtered sample of the liquid gives a reddish precipitate with a small quantity of carbonate of potassium. If the quantity of ferric oxide be sufficient, and the proportion of carbonate of potassium rightly adjusted, the whole of the arsenic acid and ferric oxide may be precipitated. If the copper and bismuth be then removed by sulphuretted hydrogen, it only remains to separate the nickel from the cobalt. (Berthier.)

3. Finely powdered cobalt-ore is carefully roasted, and 1 pt. of it added in successive small portions to 3 pts. of acid sulphate of potassium heated to the melting point in an earthen or cast-iron crucible. The mass, which is thereby rendered pasty, is then more strongly heated till it fuses quietly and no longer gives off fumes of sulphuric acid, as it is necessary to drive away the excess of that acid. The mass, while yet liquid, is then taken out of the crucible with an iron spoon — broken to pieces after cooling — dissolved in boiling water, and filtered from the arsenates of iron and cobalt, which are not soluble in a neutral liquid. Sulphuretted hydrogen is then passed through the filtrate to throw down any antimony, bismuth, or copper that may be present — the liquid again filtered, and pure carbonate of cobalt precipitated by carbonate of potassium. To prevent the formation of arsenate of cobalt, the roasted cobalt-ore, before fusion with sulphate of potassium, may be mixed with a small quantity of ferrous sulphate, so that the arsenic acid may combine with the oxide of iron contained in that salt in preference to the oxide of cobalt. No nickel is taken up by the liquid, because the sulphate of nickel is decomposed at a red heat [not so, however, the sulphate of nickel and potassium, unless the heat applied is very strong]. The solution retains but a trace of iron at the utmost. (Liebig, Pogg. Ann. xviii, 164.)

4. One part of pulverised smaltine or cobalt-glance is fused in a covered earthen crucible with 3 pts. of carbonate of potassium and 3 pts. of sulphur, whereby the whole of the metals present are converted into sulphides, and sulphide of potassium is formed, which unites with the sulphide of arsenic, forming a soluble sulpharsenate. The heat must be so regulated that the sulphide of cobalt may not fuse, but remain in the form of a crystalline powder, because, if fusion takes place, portions of the sulpharsenate of potassium will be enclosed in the fused mass, and will be difficult to wash out. The mass is then freed from sulpharsenate of potassium by repeated exhaustion with water and decantation; again treated with carbonate of potassium and sulphur, and then with water to remove the rest of the arsenic; afterwards dissolved in nitric acid or in dilute sulphuric acid mixed with nitric; the solution is treated with sulphuretted hydrogen to remove any remaining arsenic, together with bismuth and copper; and the filtered liquid is treated as in method *b*, to separate the cobalt from nickel and iron. (Wöhler, Pogg. Ann. vi. 277.)

5. To obtain cobalt from black earthy cobalt ore, the mineral is dissolved in hydrochloric acid; the arsenic, antimony, lead, and copper are precipitated by sulphuretted hydrogen; the filtrate is boiled with nitric acid to promote the further oxidation of the iron; the iron is precipitated by boiling with acetate of sodium, and the cobalt separated from the filtrate by sulphuretted hydrogen, which leaves acetate of manga-

were undecomposed. The precipitate is free from nickel, but contains a trace of zinc. The liquid freed from arsenic and copper by sulphuretted hydrogen may likewise be precipitated by sulphide of potassium or barium, and the washed precipitate treated with cold dilute hydrochloric acid, which dissolves the sulphides of manganese, zinc, and iron, and leaves all the sulphide of cobalt undissolved. (**Wackenroder**, N. Br. Arch. xvi. 133.)

The greatest difficulty in the preparation of pure cobalt-compounds is the separation of the nickel. Laugier's method (*vid. sup.*), affords the means of obtaining a cobalt solution free from nickel; but it leaves a certain portion of the cobalt in the nickel precipitate. For more complete modes of separation, adapted to quantitative analysis, see COBALT, DETECTION AND ESTIMATION OF (p. 1046).

Metallic Cobalt.—Cobalt is reduced from its oxides by ignition with charcoal more easily than iron, or the difficultly fusible brittle metals; when thus reduced, however, it contains carbon. The purest metal is obtained by igniting the oxalate in a covered crucible, the salt, $Co''C^2O^4$, being then resolved into 2 at. cobalt and 2 at. carbonic anhydride. If the oxalate or the mixture of oxide and charcoal be covered with pounded glass free from reducible metals, and heated in a blast-furnace, the cobalt is obtained in the form of a fused regulus. Cobalt may also be reduced from its oxides by hydrogen; and if the heat applied be not very great, the reduced metal is pyrophoric, like iron reduced under similar circumstances, and takes fire on coming in contact with the air, producing cobaltoso-cobaltic oxide.

Cobalt rendered compact by fusion is rather hard, has a granular fracture, and is somewhat malleable at a red heat. The presence of arsenic, manganese, &c., renders it brittle. It has a steel-grey colour, inclining to red; in the polished state, however, rather to white. The statements respecting its specific gravity vary from 8·513, (**Berzelius**), to 8·7 (**Lampadius**). That of the metal reduced by hydrogen was found by Rammelsberg, in five experiments, to vary from 8·132 to 9·495; mean 8·957. Specific heat = 0·10696 (**Regnault**), 0·1172 (**De la Rive and Marcet**). It fuses more easily than iron, less easily than gold. It is attracted by the magnet, and is capable of receiving a slight magnetic power when rubbed with a magnet, this power, according to Pouillet, not being destroyed by the strongest red heat. A minute quantity of arsenic destroys the magnetic power.

Cobalt is not altered by the action of air and water at ordinary temperatures, but when very strongly heated, it takes fire, and is converted into cobaltoso-cobaltic oxide, Co^6O^7. It decomposes aqueous vapour at a red heat. It is dissolved by hydracids and by dilute oxygen acids, with evolution of hydrogen, slowly however, and only when heated. The solutions have a fine red colour, and contain salts corresponding in composition to the protoxide. It is easily dissolved by nitric acid, likewise forming a proto-salt.

Cobalt forms several classes of compounds, the most numerous, and generally speaking the best defined being the di-compounds or cobaltous compounds, *e. g.* $CoCl^2$, CoO, CoS, $CoSO^4$, &c.; there are likewise cobaltic- or tri-compounds, *e. g.* Co^2O^3, Co^2S^3; three oxides intermediate between the two preceding; a dioxide, CoO^2, a disulphide, CoS^2, a tricobaltic phosphide, Co^3P^2, and several classes of salts containing bases in which cobalt is united with the elements of ammonia.

COBALT, ALLOYS OF. Cobalt unites readily by fusion with **antimony** and **arsenic**, the combination being attended with incandescence; the resulting alloys are brittle, and have an iron-grey colour.

Diarsenide of Cobalt, $CoAs^2$, is found native as **smaltine** or **tin-white cobalt**, being in fact the most abundant of cobalt ores. It occurs in crystals belonging to the regular system, viz. cubes, octahedrons, dodecahedrons, and intermediate forms. Cleavage octahedral, distinct; cubic, in traces. It occurs also massive and in reticulated and other imitative shapes. Specific gravity 6·3 to 6·6. Hardness 5·5. Lustre metallic. Colour tin-white, inclining sometimes to steel-grey, sometimes to silver-white. It tarnishes by exposure. Streak greyish-black. Brittle. Emits a smell of arsenic when broken. It yields no sublimate when heated in a test-tube; but in a tube open at both ends a sublimate of arsenious acid is formed. It dissolves in nitric acid, leaving a residue of arsenious acid.

Arsenide of cobalt is never found quite pure, the cobalt being always more or less replaced by nickel or iron; those varieties which contain more nickel than cobalt are called *Cloanthite* (see NICKEL). The following are analyses of smaltine containing little or no nickel; *a*, from Riechelsdorf in Hesse, by **Stromeyer** (Gött. gelehrte Anzeige, 1817, p. 72); *b*, from Tunaberg in Sweden, by **Varrentrapp** (Pogg. Ann. xlviii. 505); *c*, from Schneeberg in Saxony, by **E. Hofmann** (*ibid.* xxv. 485); *d*, from the same locality, by v. Kobell; *e*. from Riechelsdorff, by **Jäckel** (*Rammelsberg's Mineralchemie*, p. 23):—

	As	Co	Fe	Cu	Ni	Bi	S	
a .	74·21	20·31	3·42	0·16	—	—	0·88	= 98·98
b .	69·46	23·44	4·95	—	—	—	0·90	= 98·75
c .	70·37	13·95	11·71	1·39	1·79	0·01	0·66	= 99·88
d .	71·08	9·44	18·48	trace	—	1·00	trace	= 99·92
e .	66·02	21·21	11·60	1·90	—	0·04	0·49	= 101·26

The formula $CoAs^2$ requires 71·8 As and 28·2 Co. When the proportion of iron is considerable, as in *c*, *d*, *e*, the mineral is also called *Safflorite.* The composition of *e* agrees more nearly with the formula $(Co; Fe)^2As^3$. *Chathamite*, from Chatham in Connecticut, is chiefly an arsenide of nickel and iron containing 1·3 per cent. cobalt.

Smaltine occurs altered to cobalt-bloom by oxidation.

Triarsenide of Cobalt. Co^2As^6.—This compound also occurs native as Skutterudite or Modumite (*Tesseralkies*, *Hartkobaltkies*, *Hartkobalt*), at Skutterud, near Modum in Norway. It crystallises in the regular system, exhibiting faces of the cube, octahedron, dodecahedron, and trapezohedron. Cleavage cubic, distinct; dodecahedral in traces. Also massive, granular. Specific gravity 6·74—6·84. Hardness = 6. Lustre bright metallic. Colour between tin-white and pale grey, sometimes iridescent. A crystallised specimen analysed by Wöhler (Pogg. Ann. xliii. 591), gave 79·2 As, 18·5 Co, 1·3 Fe = 99·0, the formula requiring 78·2 per cent. As and 20·8 Co. This mineral heated in a closed tube yields a sublimate of metallic arsenic.

When smaltine is ignited in a retort, part of the arsenic is expelled, and there remains a lower arsenide of cobalt, which is non-magnetic, and fuses before the blowpipe to a brittle metallic globule. In cobalt-blue works, crystallised alloys of cobalt and arsenic are often formed, containing also copper and iron. (Scheerer and Francis, Pogg. Ann. l. 513.)

With $\frac{1}{16}$ of its weight of gold, cobalt forms, according to Hatchett, a dark yellow very brittle compound; even $\frac{1}{35}$ pt. of cobalt is sufficient to render gold brittle.

The alloy of cobalt with iron is very hard and difficult to pulverise.

With mercury, cobalt forms a silver-white amalgam, which is attracted by the magnet

With platinum, it forms a fusible compound.

When cobalt is fused with silver, two layers are formed, the lower consisting of cobaltiferous silver, the upper of argentiferous cobalt; a small quantity of cobalt renders silver brittle.

With tin, cobalt forms a somewhat ductile alloy of light violet colour.

With zinc, it unites only with great difficulty, also with lead and bismuth, which exhibit with cobalt the same deportment as silver.

COBALT, BROMIDE OF. $CoBr^2$.—Cobalt takes up bromine-vapour at a dull red heat, forming a green compound which melts, and at a higher temperature suffers partial decomposition. The compound deliquesces rapidly in the air, forming a red liquid. The same solution is obtained by heating finely divided cobalt with bromine and water. It turns violet-red on evaporation, and leaves a green mass when evaporated to dryness. By evaporating the solution over oil of vitriol, red crystals of the hydrated bromide acid are obtained, which soon effloresce in the dry air of the receiver, but deliquesce when exposed to the air in its ordinary state. (Rammelsberg.)

A solution of the bromide forms, with excess of *ammonia*, a blue precipitate, which turns green on exposure to the air, and a red solution which turns brown in the air, and then sometimes deposits red quadratic tables, perhaps consisting of a compound of Co^2Br^6 with bromide of ammonium. (Rammelsberg.)

Bromide of cobalt absorbs *ammonia-gas*, forming ammonio-bromide of cobalt, $6NH^3.CoBr^2$, a red powder which gradually turns brown, and is resolved by water into a brown solution, and an insoluble green residue containing bromine. (Rammelsberg.)

COBALT, CHLORIDES OF. The *dichloride*, $CoCl^2$, is formed, with vivid incandescence, when pulverulent cobalt is heated in a stream of chlorine-gas; it then sublimes in blue crystalline scales. It is also produced in the wet way by dissolving cobalt or the protoxide in hydrochloric acid, hydrogen being evolved in the former case, or by heating the sesquioxide, or cobaltoso-cobaltic oxide (Co^3O^4), with hydrochloric acid, its formation being then attended with evolution of chlorine. The solution is pink, and yields by evaporation non-deliquescent crystals of the same colour, consisting of hydrated chloride of cobalt. But if the pink solution be mixed with strong hydrochloric or sulphuric acid, it turns blue the more readily as it is more concentrated and more strongly heated. The effect appears to be due to the abstraction of the crystallisation-water by the strong acid. According to Proust, such a solution sometimes deposits the blue crystals of the anhydrous chloride. The red colour is restored by dilution with water. By evaporating the solution to dryness, or by heating the hydrated crystals, hydrochloric acid is evolved, and a greenish blue mass is obtained, consisting of an oxychloride (Berzelius), which is decomposed at a higher temperature, yielding a sublimate of anhydrous chloride, and leaving an oxidised compound.

The sublimed chloride forms soft loose crystalline spangles, unctuous to the touch, and of light blue colour. On exposure to the air, it takes up water and becomes rose-red, and is then easily dissolved by water, forming a red solution; but if not previously hydrated in this manner, it is very slowly dissolved by water.

The red solution forms a sympathetic ink. Characters written with it on paper are colourless and invisible or nearly so; but when the paper is warmed by holding it near a fire, the writing becomes visible and appears of a beautiful blue. After a while, as the salt absorbs moisture, the colour disappears, but may be reproduced by the action of heat. If the paper be exposed to too high a temperature, the writing becomes black, and does not afterwards disappear. The addition of a nickel-salt to the solution gives a green instead of a blue colour.

Ammonio-chloride of Cobalt, $4NH^3.CoCl^2$, obtained by passing ammonia-gas over the heated chloride, is a bulky powder of a pale reddish-white colour. With water it forms a red-brown solution, and leaves a green powder. (H. Rose.)

Trichloride of Cobalt, Co^2Cl^6, is a very unstable compound, formed by dissolving hydrated cobaltic oxide in cold hydrochloric acid. A brown solution is thus obtained, which begins to evolve chlorine, and pass into the protochloride, this effect taking place instantly on heating the liquid. The sesquichloride is also formed in small quantity when chlorine is passed through a solution of the protochloride mixed with hydrochloric acid, the liquid then assuming a darker colour.

COBALT, DETECTION AND ESTIMATION OF. 1. *Blowpipe Reactions.*—All compounds of cobalt fused with borax or phosphorus-salt before the blowpipe, either in the inner or the outer flame, impart a splendid blue colour to the bead, affording an extremely delicate test of the presence of the metal. The production of the blue colour in *both* flames distinguishes cobalt from all other metals. If the substance under examination contains a large quantity of manganese or iron, as well as cobalt, the bead formed in the outer flame is violet in the former case, green in the latter. If the glass be then heated in the reducing flame, the manganese colour disappears, and that of iron changes to bottle green, the glass then exhibiting either the pure blue due to cobalt, or the greenish blue of a mixture of cobalt and iron.

Cobalt-salts mixed with carbonate of sodium, are reduced on charcoal to a grey magnetic powder of metallic cobalt.

2. *Reactions in Solution.*—Solutions of proto-salts of cobalt or cobaltous salts have a rose-red colour, excepting when they are very concentrated and contain a free acid, in which case they are blue; dilution with water changes the blue colour to red (p. 1042). The neutral solutions faintly redden litmus. *Sulphydric acid* produces no precipitate in cobalt solutions containing an excess of either of the stronger acids; but in a solution of the acetate, or of any cobalt-salt mixed with acetate of potassium it forms a black precipitate of sulphide of cobalt. *Alkaline sulphides* throw down the same precipitate, insoluble in excess of the reagent.

Potash or *soda* forms in cobaltous solutions a blue precipitate of a basic salt, which is insoluble in excess of the reagent, assumes a green or dirty bluish-grey colour on exposure to the air, from formation of sesquioxide, but if protected from the air, is converted into the hydrated protoxide of a dingy red colour. This last change takes place quickly on heating the liquid, even if the air be not excluded. A solution of protochloride of cobalt containing a little sesquichloride, yields with potash a precipitate which does not change to dingy red, even on boiling, but merely acquires a darker colour.

Ammonia added in small quantity to a cobaltous solution forms a blue precipitate consisting of a basic salt, which, by continued digestion with ammonia out of contact of air, is converted into rose-red hydrated cobaltous oxide, the change being, however, much slower than when a fixed alkali is used as the precipitant. In contact with the air, the precipitate becomes green. If more ammonia be added, it dissolves and forms a brownish-red liquid, which, if exposed to the air, absorbs oxygen, becomes red-brown, and then contains salts of various bases, consisting of the elements of ammonia united with the higher oxides of cobalt (see COBALT-BASES, AMMONIACAL). If the solution contains but a small quantity of ammoniacal salts, which will be the case if the original cobalt solution was neutral, potash produces in it a precipitate of hydrated sesquioxide of cobalt; but if chloride of ammonium be added, or if the original solution contained an excess of acid which has been neutralised by the ammonia, potash produces no precipitate.

Neutral *carbonate of potassium* or *sodium*, forms a rose-coloured precipitate of hydrocarbonate of cobalt, which, when boiled, gives off carbonic acid, and assumes a violet, or, if the alkaline carbonate is in excess, a blue colour. If the precipitate be boiled for some time in contact with the air, its colour changes to green. A solution of *acid carbonate of potassium* forms, in neutral cobaltous solutions, a rose-coloured precipitate, with evolution of carbonic acid, the liquid retaining a reddish colour which it does not lose for a very long time. The precipitate ultimately changes to a mass of small rose-coloured crystals, consisting of a compound of neutral carbonate of cobalt with acid carbonate of potassium. Frequently, also, there is formed a compact precipitate, destitute of crystalline structure, and consisting of a compound of neutral carbonate of cobalt with a very small quantity of cobaltous hydrate.—*Carbonate of ammonium* produces a red precipitate of carbonate of cobalt, soluble in excess of the precipitant and in chloride of ammonium; the solution does not turn brown in contact with the air.

Carbonate of barium does not in general precipitate cobaltous salts at ordinary temperatures; from a solution of the sulphate, however, the greater part of the cobalt is precipitated after a very long time, so that the remaining liquid is nearly colourless. From a solution of the chloride, no precipitation takes place in the cold, but by prolonged boiling, the whole of the cobalt is precipitated.

Oxalic acid produces, after some time, a faintly reddish white precipitate, which gradually increases, the whole of the cobalt being ultimately thrown down as oxalate. The precipitate is soluble in ammonia, less easily in carbonate of ammonium. The rose-coloured ammoniacal solution, when exposed to the air, very slowly deposits the oxalate.

Phosphate of sodium produces in neutral cobaltous solutions, a blue precipitate of cobaltous phosphate, soluble with red colour in excess of the cobalt-solution, deposited again on boiling, and redissolving as the liquid cools.

Cyanide of potassium produces a red-brown precipitate completely soluble in excess. The solution has a grass-green colour, changing, after a while, to pale brown, and yields, with hydrochloric acid, a reddish-white precipitate, soluble in potash. Sulphide of ammonium does not precipitate the cobalt from this solution, even after a long time.

Ferrocyanide of potassium produces a green precipitate of ferrocyanide of cobalt, changing after a while to grey; insoluble in hydrochloric acid. *Ferricyanide of potassium* produces a reddish-brown precipitate, likewise insoluble in hydrochloric acid.

Brown peroxide of lead mixed with the solution of a cobaltous salt, precipitates nearly all the cobalt, after some time, in the form of sesquioxide; the reaction is accelerated by heat.

The non-precipitation by sulphydric acid in presence of free mineral acids, and the reactions with alkalis,—especially the formation of a brownish-red solution with excess of ammonia, from which sulphide of ammonium throws down a black precipitate,—are together sufficient to distinguish cobaltous solutions from all others. The blowpipe reaction will of course be resorted to as a confirmatory test.

Many non-volatile organic substances, such as tartaric acid, prevent the precipitation of cobalt by alkalis, but not by sulphide of ammonium.

Tri-salts of cobalt, or cobaltic salts.—The liquid formed by passing chlorine into a solution of a cobaltous salt, or by treating it with chlorate of potassium and hydrochloric acid, till it assumes a brown-red colour and smells strongly of chlorine, exhibits the following reactions:—

Sulphydric acid produces no precipitate, but only a milkiness arising from separation of sulphur, the solution at the same time acquiring the rose-red colour characteristic of cobaltous salts. *Sulphide of ammonium*, after saturation of the free acid by ammonium, produces a black precipitate of sulphide of cobalt. *Potash*, a dark black-brown precipitate of hydrated cobaltic oxide. *Ammonia*, a brownish-red solution, which does not change by contact with the air. *Carbonates of potassium and sodium*: green solution which deposits a small quantity of sesquioxide. *Ferrocyanide of potassium*, a green; and *ferricyanide of potassium*, a brownish-red precipitate. *Oxalic acid* slowly produces a precipitate of cobaltous oxalate.

3. *Quantitative estimation.*—Cobalt is generally precipitated from its solutions by *caustic potash*. The basic salt at first thrown down is converted into hydrate (p. 37) by boiling in the liquid, and then well washed with hot water to free it from alkali, which adheres very obstinately to it. It is then dried and ignited in an atmosphere of hydrogen, by which it is reduced to the metallic state. The reduction is most easily performed by placing the dried precipitate in a platinum or porcelain crucible, through the lid of which passes a tube connected with a hydrogen apparatus. The crucible must be heated to full redness over a lamp; if a lower degree of heat be applied, the reduced cobalt will be pyrophoric, and is sure to oxidise partially during weighing. The stream of hydrogen must be kept up till the crucible is quite cold.

As the precipitate thrown down by potash almost always retains a small quantity of alkali, even after prolonged washing, the reduced metal must, after weighing, be well washed with water, till the liquid which runs away no longer exhibits any alkaline reaction. The metal is then to be dried, again ignited in hydrogen gas, and weighed. The difference between the two weighings seldom exceeds 0·2 per cent. If the cobalt has been precipitated from a solution of the sulphate, the precipitate may retain a small quantity of sulphuric acid: in that case, the reduced metal will contain sulphur, but never more than a mere trace, unless the precipitate has been boiled with the liquid for a very long time.

Alkaline carbonates do not precipitate cobalt so completely as the caustic alkalis.

If the cobalt-solution contains ammoniacal salts, the precipitation is not complete even when a caustic alkali is used, and the liquid well boiled. In that case it is necessary to precipitate by *sulphide of ammonium*, wash the precipitate, dry it on the filter, burn the filter to ashes, then dissolve the sulphide in nitric or nitromuriatic acid, and precipitate with potash as above.

If the solution contains none but easily volatile acids, such as nitric or hydrochloric acid, and no fixed base but cobalt, the precipitation may be dispensed with altogether, the liquid being merely evaporated to dryness in the crucible, and the residue ignited in an atmosphere of hydrogen, in the manner already described.

Lastly, cobalt may be completely precipitated from its neutral solutions by *nitrite of potassium*, in the form of potassio-cobaltic nitrite, or cobalt-yellow (p. 1058). The solution is evaporated to a small bulk, and neutralised by potash if it contains excess of acid. A solution of nitrite of potassium is then added, together with sufficient acetic acid to neutralise any free potash in the nitrite: the whole is left at rest for two days, and the yellow compound which has separated is collected on a filter. The filtered liquid should also be treated with nitrite of potassium and acetic acid, and left at rest for some time, in order to see whether any further precipitate forms. The precipitate is washed with solution of chloride or sulphate of potassium, then dissolved in hydrochloric acid, the liquid being heated till it is quite free from nitrous acid, and exhibits the rose-red colour of a cobaltous salt, and the cobalt is finally precipitated by potash. This mode of precipitation serves to separate cobalt from nickel, zinc, manganese, and many other metals. (A. Stromeyer, Ann. Ch. Pharm. xcvi. 218.)

4. *Separation from other elements.*—The metals of the first group (i. 217), are separated from cobalt by precipitating them with *sulphydric acid*, from solutions acidulated with one of the stronger mineral acids. From the metals of the third group and from the non-metallic elements, cobalt is separated by precipitating it as a sulphide with *sulphide of ammonium* from neutral or alkaline solutions. In applying this method to the separation of cobalt from magnesium, it is necessary to add chloride of ammonium to retain the magnesia in solution, and even then the sulphide of cobalt sometimes carries down with it a small quantity of magnesia. This may, however, be prevented by boiling the whole till the free ammonia present is volatilised, then adding a few drops of sulphide of ammonium, and filtering.

Aluminium is best separated from cobalt by precipitation as insoluble diacetate (i. 13). The solution, if acid, is neutralised with carbonate of sodium, *acetate of sodium* is added, and the liquid boiled for some time. The alumina is then precipitated in a form in which it may be easily filtered and washed. The washing must be performed with a warm weak solution of acetate of sodium, as the precipitate is slowly dissolved by pure water. The whole of the cobalt remains in solution, and the alumina, which may contain soda, is dissolved by hydrochloric acid, and precipitated by sulphide of ammonium (i. 155). (H. Rose.)

Aluminium cannot be separated from cobalt by *solution of potash*, the precipitated oxide of cobalt always carrying some of the alumina with it. A better method is to fuse the mixture of the two bases with solid potash in a silver crucible, and extract the fused mass with water. The oxide of cobalt which then remains may contain a little potash, but it is free from alumina.

Another very good mode of separation is to mix the solution of the two bases with tartaric acid and excess of ammonia,—which will not then precipitate either of them,—and add sulphide of ammonium, which will throw down the cobalt and leave the aluminium in solution. The precipitated sulphide of cobalt is then to be treated with nitric acid, &c., as already explained; the filtrate containing the alumina evaporated to dryness, and the residue ignited to burn away the organic matter. If no other base is present, the ignited residue will consist of pure alumina, which may be weighed; in the contrary case, the residue must be dissolved in hydrochloric acid, and the alumina precipitated by one of the methods given on page 155. As the burning away of the organic matter takes a long time, it is perhaps better to destroy it by boiling the liquid with chlorate of potassium and hydrochloric acid, and then precipitate the alumina.

Cobalt may also be separated from aluminium by precipitation with *nitrite of potassium*.

From glucinum, cobalt may be separated by either of the two methods last-mentioned; also from yttrium, zirconium, thorium, cerium, lanthanum and didymium. The last three metals may also be separated from cobalt by precipitation with *sulphate of potassium* (i. 833), or with oxalic acid from a solution containing excess of ammonia.

From iron, cobalt is most easily separated by precipitating the two metals with *sulphide of ammonium*, and digesting the washed precipitate in dilute hydrochloric acid, which dissolves the iron and leaves the cobalt. As, however, very small quantities of sulphide of cobalt may likewise be dissolved, it is best to reprecipitate the iron by sulphide of ammonium, and treat the precipitate with very dilute hydrochloric acid: any slight traces of cobalt that may be mixed with the iron will then be left undissolved.

Cobalt may also be separated from iron (in the state of sesquioxide) in the same manner as aluminium, viz. by boiling the neutralised solution with *acetate of sodium*. The iron is then precipitated, while the cobalt remains in solution. The iron precipitate is washed with warm dilute acetate of sodium, dissolved in hydrochloric acid, and the iron reprecipitated by ammonia; and the cobalt is precipitated by sulphide of ammonium. If the iron in the original solution is in the state of protoxide, it must first be converted into sesquioxide by heating with nitric acid. This method yields very exact results.

A third method of separating iron (as sesquioxide) from cobalt, is to mix the solution, if neutral, with a considerable quantity of chloride of ammonium, then cautiously add ammonia till a permanent precipitate of ferric oxide just begins to form, and precipitate the rest of the iron with *succinate of ammonium*. The cobalt remains in solution, and the ferric succinate, after being washed and dried, is ignited with good access of air, to prevent reduction of iron by the organic matter (see IRON). This method is not, however, so good as the two preceding, as the oxide of iron, when examined by the blowpipe, always exhibits the presence of a small quantity of cobalt.

Lastly, cobalt may be separated from iron by precipitation with *nitrite of potassium*.

From manganese (existing in solution as a manganous salt) cobalt may be easily separated by precipitating the two metals as sulphides, and dissolving out the sulphide of manganese with dilute hydrochloric acid, in the same way as for iron.

Another method, proposed by Liebig, is to precipitate the two metals as cyanides with *cyanide of potassium*, then add a sufficient excess of that reagent to redissolve the cyanide of cobalt and part of the cyanide of manganese. The latter is collected on a filter and washed; the filtered liquid is heated, and hydrochloric acid is slowly added by drops, care being taken not to add enough to render the liquid acid; and the separation of the cobalt and manganese is effected exactly in the manner which will be presently described for the separation of cobalt and nickel. The cyanide of manganese previously separated by filtration is dissolved in hydrochloric acid; the solution is boiled till the hydrocyanic acid is completely volatilised, the manganese is precipitated by carbonate of sodium, and the quantity thus obtained is added to that determined the other way.

If the cobalt and manganese exist in solution as chlorides, the liquid may be evaporated to dryness (being transferred to a porcelain crucible when reduced to a small bulk), and the residual chlorides ignited in an atmosphere of *hydrogen* in the manner described at p. 1043, as long as vapours of hydrochloric acid continue to escape. The cobalt is then reduced to the metallic state, while the chloride of manganese remains undecomposed, and may be dissolved out by water. The metallic cobalt which remains is washed with hot water, then digested with a small quantity of very dilute acetic acid, to dissolve out any small quantity of chloride of manganese that may remain, afterwards ignited in a current of hydrogen, and weighed. The manganese is precipitated from the solution of its chloride by carbonate of sodium. If the temperature be raised too high during the reduction by hydrogen, a small quantity of chloride of manganese may be volatilised.

Another mode of separating cobalt from manganese, is to digest the mixed protoxides (precipitated by an alkali) in a solution of *pentasulphide of calcium*, which converts them both into sulphides, dissolving the sulphide of cobalt, and leaving the sulphide of manganese undissolved.

From nickel, as from most other metals of the second group, cobalt is most easily separated by precipitation with *nitrite of potassium*, the process being performed exactly as described at p. 1045. With due attention to the precautions there indicated, the whole of the cobalt is precipitated, without a trace of nickel.

Another method is that of H. Rose, depending on the fact that protoxide of cobalt in solution is converted by *chlorine* into sesquioxide, whereas with nickel this change does not take place. The metals or their oxides being dissolved in excess of hydrochloric acid, the solution is diluted with a large quantity of water, about a pound of water to a gramme of the metals or their oxides. Chlorine gas is then passed through the solution for several hours, till, in fact, the space above the liquid becomes permanently filled with the gas; carbonate of barium is then added in excess; and the whole is left to stand for twelve or eighteen hours, and shaken up from time to time. The precipitate, consisting of sesquioxide of cobalt and carbonate of barium, is then collected on a filter, and washed with cold water. The filtered liquid, which has a pure green colour, contains all the nickel without a trace of cobalt. The precipitate is boiled with hydrochloric acid to convert the sesquioxide of cobalt into protoxide, and dissolve it together with the baryta; the latter is then precipitated by sulphuric acid, and the cobalt from the filtrate by potash. The nickel is also precipitated by potash, after the removal of any baryta that the solution may contain by sulphuric acid. This method, if properly executed, gives very exact results. The chief precautions to be attended to, are to add a large excess of chlorine, and not to filter too soon, because the precipitation of sesquioxide of cobalt by carbonate of barium takes a long time.

According to Henry, *bromine* may be used in the preceding process instead of chlorine as the oxidising agent.

Liebig has given several methods of separating these two metals, founded on the difference of their reactions with *cyanide of potassium*. 1. The oxides of the two metals are treated with hydrocyanic acid and then with potash, and the liquid warmed till the whole is dissolved (pure cyanide of potassium, free from cyanate, may also be used as the solvent). The reddish-yellow solution is boiled to expel free hydrocyanic acid, whereupon the cobaltocyanide of potassium ($K^2Co''Cy^4$), formed in the cold, is converted into cobalticyanide ($K^6(Co^2)^{vi}Cy^{12}$), while the nickel remains in the form of cyanide of nickel and potassium ($K^2Ni''Cy^4$). Pure and finely-divided red oxide of mercury is then added to the solution while yet warm, whereby the whole of the nickel is precipitated, partly as oxide, partly as cyanide, the mercury taking its place in the solution. The precipitate contains all the nickel, together with excess of mercuric oxide; after washing and ignition, it yields pure oxide of nickel. The filtered solution contains all the cobalt in the form of cobalticyanide of potassium. It is supersaturated with acetic acid, boiled with sulphate of copper, which precipitates the cobalt in the form of cobalticyanide of copper ($\overset{\prime\prime}{Cu}{}^3(Co^2)^{vi}Cy^{12}.14H^2O$), and the precipitate retained in the liquid at a boiling-heat till it has lost its glutinous character. It is then washed, dried, ignited, and dissolved in hydrochloric acid mixed with a little nitric acid; the copper is precipitated by sulphydric acid; and the filtrate, after boiling for a minute to expel the excess of that gas, is mixed with boiling caustic potash to precipitate the cobalt (Ann. Ch. Pharm. lxv. 244).—2. Instead of adding the oxide of mercury, the solution containing the mixed cyanides may, after cooling, be supersaturated with chlorine, the precipitate of cyanide of nickel thereby produced being continually redissolved by caustic potash or soda. The chlorine produces no change in the cobalticyanide of potassium, but decomposes the nickel-compound, the whole of the nickel being ultimately precipitated in the form of black sesquioxide. (Ann. Ch. Pharm. lxxxvii. 128.)

Liebig's first method (*ibid.* xli. 291), which consisted in treating the solution of the mixed cyanides with excess of hydrochloric or sulphuric acid, whereby the nickel was precipitated as cobalticyanide of nickel, leaving a solution of cobalticyanide of potassium, has been found, both by himself and others, not to give perfectly satisfactory results. The method by oxalic acid (p. 1040), and the precipitation of nickel from an ammoniacal solution of the two metals by potash (see NICKEL) are not sufficiently accurate for quantitative analysis.

F. Claudet separates cobalt from nickel and other metals in the form of the ammonio-compound described on page 1052, that compound being very insoluble, while corresponding compounds of the other metals do not appear to be formed under the same circumstances.

From uranium, in the state of sesquioxide, cobalt, as protoxide, may be separated by means of carbonate of barium, which throws down the uranic oxide and leaves the cobalt in solution. (For other modes of separation, see URANIUM.)

From zinc, cobalt may also be easily separated by precipitation with *nitrite of potassium.* Another mode of separation is: Convert the two metals into chlorides, and reduce the chloride of cobalt with hydrogen, as described for the separation of cobalt from manganese; the chloride of zinc then remains unaltered, and may be dissolved out. Thirdly, the metals may be precipitated by carbonate of sodium, the carbonates dissolved in a large excess of acetic acid, and sulphydric acid gas passed through the solution. The zinc is thereby precipitated as sulphide, while the cobalt remains dissolved. To ensure complete separation, it is necessary to add a large excess of acetic acid. Fourthly, the separation may be effected by precipitating the cobalt as sesquioxide, by means of peroxide of lead (p. 1044).

5. *Valuation of Cobalt-ores.*—The value of a cobalt-ore is estimated either by the amount of protoxide that it will yield, or by its power of imparting a blue colour to glass and enamel. (For the latter mode of valuation we refer to the article SMALT.)

To estimate the quantity of protoxide contained in a cobalt ore, the ore may be treated by either of the methods already given (pp. 1039, 1040), to separate the arsenic, copper, iron, &c., the cobalt being afterwards separated from the nickel, and estimated by either of the processes described on pp. 1044. 1045.

(For Plattner's method of estimation in the dry way, see his *Treatise on the Blowpipe*, translated by Muspratt, also *Kerl's Hüttenkünde*, iii. [1] 340, 342).

6. *Atomic Weight of Cobalt.*—Dumas has determined the atomic weight of cobalt by the quantity of silver required to decompose a known weight of the chloride. Pure metallic cobalt was dissolved in nitro-muriatic acid, the solution evaporated to dryness, keeping the hydrochloric acid continually in excess; the residue ignited in a stream of hydrochloric acid gas, or else heated in vacuo; and the chloride of cobalt thus obtained was decomposed by nitrate of silver. Five experiments thus made gave for the atomic weight of cobalt, numbers varying from 59·0 to 59·18. Dumas regards 59 as the correct number (Ann. Ch. Pharm. cxiii. 24). This agrees with the original determination of Rothof (Pogg. Ann. viii. 185), which was made by converting a known weight of the protoxide into chloride, and then precipitating by nitrate of silver. Schneider (Pogg. Ann. ci. 317), from the analysis of the oxalate, estimated the atomic weight of cobalt at 60; but the number 59 is generally regarded as correct.

COBALT, EARTHY, or *Asbolan.*—A variety of wad or earthy manganese, containing oxide of cobalt. (See WAD, and MANGANESE, OXIDES OF.)

COBALT, FLUORIDE OF, $Co''F^2$, may be obtained by dissolving cobaltous oxide or carbonate in aqueous hydrofluoric acid. The solution yields by evaporation small irregular rose-coloured crystals containing $Co''F^2.2H^2O$. The compound dissolves without decomposition in water containing free hydrofluoric acid, or in a small quantity of pure water; but with a larger quantity of water, it is resolved into an acid liquid containing cobalt, and an insoluble pale red basic salt consisting of $2Co^2F^2O.H^2O$.

Fluoride of cobalt unites with the fluorides of ammonium and potassium, forming sparingly soluble double salts which crystallise in pale red granular crystals. (Berzelius.)

COBALT, IODIDE OF, $Co''I^2$, is produced by digesting finely divided metallic cobalt with iodine and water, the mixture becoming heated to the boiling point. With a small quantity of water it forms a green, and with a larger quantity, a red solution, and remains, on evaporation, as a dark green deliquescent mass soluble in alcohol. (Erdmann, J. pr. Chem. vii. 354.)

Ammonio-iodides of Cobalt.—Iodide of cobalt absorbs 3 at. ammonia-gas, forming the compound, $Co'I^2.4NH^3$, which is a reddish-yellow powder. A concentrated solution of iodide of cobalt forms with ammonia a reddish-white precipitate which dissolves on heating, leaving only a few green flocks. The solution deposits small rose-coloured crystals, which, as well as the reddish-white precipitate, consist of $Co''I^2.4NH^3$, but appear also to contain water. When dried, they give off ammonia, turn brown and afterwards green. Water decomposes them, liberating ammonia and depositing a green powder. A dilute solution of iodide of cobalt forms with ammonia a blue precipitate which turns green when exposed to the air, and a brown solution. (Rammelsberg, Pogg. Ann. xlviii. 155.)

COBALT, OXIDES OF. The following oxides of cobalt are known:

Protoxide or cobaltous oxide	$Co''O$
Sesquioxide or cobaltic oxide	Co^2O^3
Intermediate oxides	Co^3O^4
	Co^6O^7
	Co^8O^9

The protoxide is a strong, the sesquioxide a weak base. According to Frémy, the oxide Co^2O^2 is also a salifiable base, which unites directly with acetic acid and exists in some of the ammoniacal salts of cobalt. Frémy has also obtained salts of this nature containing a dioxide of cobalt, Co^2O^4.

Protoxide of Cobalt or *Cobaltous Oxide*, Co^2O.—This oxide is obtained by igniting cobaltous hydrate or carbonate in close vessels; by igniting the protochloride in a stream of aqueous vapour (Schwarzenberg); also, mixed in various proportions with sesquioxide, when finely divided cobalt burns in the air, or when the compact metal is heated to redness in the air. The pure protoxide is a light greenish-grey or olive-green non-magnetic powder. It is reduced to the metallic state at a red heat by hydrogen, charcoal, carbonic oxide, potassium, and sodium. When heated with sulphur, it is converted into sulphide of cobalt and sulphurous anhydride; and with sulphydric acid, it yields water and sulphide of cobalt.

Hydrated cobaltous oxide, or Cobaltous hydrate, CoH^2O^2, or $CoO.H^2O$, is produced when a cobaltous salt is decomposed by potash out of contact of air. A blue basic salt is first produced which changes gradually at ordinary temperatures, quickly, on boiling, into the rose-coloured hydrate. If the cobalt-solution be dropped into strong boiling potash-ley, the change from blue to red is almost too rapid to be traced. Cobaltous hydrate is a powder of a dingy rose-red colour, which gives off water at 100° C., and is converted into the protoxide if the air be excluded, into a higher oxide if exposed to the air. It dissolves readily in acids, forming the cobaltous salts.

Sesquioxide of Cobalt, Cobaltic Oxide, Co^2O^3, is formed when chlorine is transmitted through water in which the hydrated protoxide is suspended, or when a salt of the protoxide is precipitated by a solution of chloride of lime. In the former case, water is decomposed by the chlorine, and hydrochloric acid produced, while the oxygen of the water peroxidises the cobalt:

$$2CoO + H^2O + Cl^2 = Co^2O^3 + 2HCl.$$

The sesquioxide of cobalt is precipitated as a black hydrate, which, when cautiously heated to 600° or 700° C., yields the black anhydrous oxide. When sesquioxide of cobalt is digested in hydrochloric acid, chlorine is evolved, and the protochloride formed. Exposed to a low red heat, the sesquioxide loses oxygen, and the compound oxide, $CoO.Co^2O^3$, is produced (Hess). When protoxide of cobalt is calcined with a borax glass, at a moderate heat, it absorbs oxygen, and a black mass is obtained, which, mixed with manganic oxide, serves as a black colour in enamel painting.

Sesquioxide of cobalt acts as a weak base. Phosphoric, sulphuric, nitric, and hydrochloric acids dissolve its hydrate in the cold, without decomposition at first, but the resulting salts are afterwards reduced to salts of the protoxide. A protosalt of cobalt containing a small quantity of a sesquisalt is somewhat deepened in colour. The most permanent of the sesquisalts is the acetate; the hydrated sesquioxide while yet moist dissolves in acetic acid, slowly but completely. The solution, which has an intense brown colour, forms a brown precipitate with *alkalis* and *alkaline carbonates*. With *ferrocyanide of potassium*, it forms a dark precipitate, which, if the precipitant is in excess, gives up cyanogen to it, converting it into ferricyanide of potassium and being itself converted into green ferrocyanide of cobalt. Alkaline *oxalates* colour the solution yellow, forming an oxalate of the oxide Co^3O^4.

Cobaltoso-cobaltic oxides.—*a.* The oxide, $Co^3O^4 = CoO.Co^2O^3$, is obtained in the free state by heating the nitrate or oxalate of cobalt, or the hydrated sesquioxide, to redness in contact with the air (Hess, Rammelsberg); but according to Beetz and Winkelblech, the oxide thus obtained is Co^6O^7. When the residue obtained by gently igniting the oxalate in contact with the air is digested in strong boiling hydrochloric acid, the oxide Co^3O^4 remains in hard, brittle, greyish-black microscopic octahedrons having a metallic lustre. The same crystalline compound is obtained by strongly igniting dry protochloride of cobalt, alone or mixed with sal-ammoniac, in dry air or oxygen gas. (Schwarzenberg.)

This oxide, according to Frémy, is also a salifiable base. The corresponding oxalate has already been mentioned. The acetate is obtained by digesting in dilute acetic acid the hydrated oxide obtained by continued action of oxygen on the blue precipitate thrown down from ordinary cobalt-salts by potash not in excess. Frémy also states that when chlorine is passed into the solution of ordinary acetate of cobalt, a brownish-yellow salt is formed containing the base $Co^3Cl^2O^3$, or Co^3O^4 in which 1 at. O is replaced by Cl^2. This chlorine-base exists also in some of the ammonio-compounds of cobalt (p. 45).

b. The oxide, $Co^6O^7 = 4CoO.Co^2O^3$, is said by Winkelblech to be formed by keeping the hydrated protoxide at a red heat in the air for a considerable time, or by first reducing it to the metallic state by heating it very gently in a stream of hydrogen, and then burning it again by passing air through the tube. According to Rammelsberg, however (Pogg. Ann. lxxiii. 93), the oxide obtained by either of these processes is Co^3O^4.

c. Another oxide, $Co^8O^9 = 6CoO.Co^2O^3$, is said to be obtained by precipitating cobaltic nitrate with ammonia, exposing the liquid to the air till the blue precipitate turns green, then suspending the precipitate in water, and exposing it to the air for a month till it turns quite yellow. But the yellow hydrate thus formed always retains a trace of nitric acid, which cannot be removed even by long contact with water.

A *cobaltic acid* (or anhydride), Co^3O^5, is obtained in combination with potash, by strongly igniting the oxide, Co^3O^4, or the protoxide or carbonate, with pure hydrate of potassium. A crystalline salt is then formed which, when dried at 100° C., contains $K^2O.3Co^3O^4 + 3$ aq., and gives off 1 at. water at 130°. (Schwarzenberg.)

Dioxide of Cobalt, CoO^2, has not been obtained in the free state, but may be supposed to exist in the oxycobaltic salts (p 1056).

COBALT, OXYSULPHIDE OF, Co^2SO, or $CoS.CoO$.—Produced by igniting the sulphate in hydrogen gas. Water and sulphurous acid escape, and there remains a dark grey sintered mass which is not altered by the further action of the hydrogen. Cold hydrochloric acid decomposes it, dissolving oxide of cobalt and leaving sulphide; but if heat be applied, the sulphide likewise dissolves. (Arfvedson.)

COBALT, OXYGEN-SALTS OF.—The cobaltous salts are produced by dissolving metallic cobalt in the stronger acids; by the action of acids on the protoxide, hydrate, or carbonate; by boiling the hydrate or carbonate in solutions of ammonia-salts, ammonia being then evolved and a cobaltous solution formed; and by precipitation. The carbonate, phosphate, borate, silicate, and those which contain metallic acids, are insoluble in water; most of the others are soluble. The insoluble salts have a violet or peach-blossom colour; the dissolved salts a rose colour. The neutral solutions redden litmus slightly. For their reactions and those of the cobaltic salts, see pp. 1043, 1044.

COBALT, PHOSPHIDES OF.—The *tricobaltic phosphide*, or *tricobalt-phosphine*, Co^3P^2, was obtained by H. Rose as a grey powder, on passing hydrogen gas over basic phosphate of cobalt ignited in a porcelain tube. It is also produced by the action of phosphoretted hydrogen on chloride of cobalt.

Another phosphide containing a very large excess of cobalt is produced when pieces of phosphorus are thrown on red-hot cobalt; when 1 pt. of the metal is ignited with 7 pts. glacial phosphoric acid and $\frac{1}{16}$ charcoal powder; and when a mixture of 70 pts. metallic cobalt or oxide of cobalt, 100 bone-ash, 50 pounded quartz, and 10 charcoal is exposed for an hour to the heat of a blast-furnace. The compound prepared by the first or second method is bluish-white, with metallic lustre, brittle, of acicular structure, more fusible than cobalt, contains 6 per cent. phosphorus, and burns to a dark blue glass when heated (Pelletier). The product obtained by the third process is of a shining white colour, very fusible, non-magnetic, and often has needle-shaped crystals in its cavities.

COBALT, RED. Syn. with COBALT-BLOOM (p. 1057).

COBALT, SELENIDE OF. Heated cobalt unites with selenium, forming a grey mass, which exhibits metallic lustre and crystalline structure, and melts at a red heat; the combination is attended with ignition. (Berzelius.)

COBALT, SULPHIDES OF. The *protosulphide*, Co^2S, occurs native as Syepoorite, a massive mineral of steel-grey colour inclining to yellow, found disseminated in grains or veins in ancient schists, associated with magnetic pyrites, at Syepoor, near Rajpootanah, in North-west India. It is employed by the Indian jewellers to give a rose-colour to gold. According to Middleton's analysis (Phil. Mag. [3] xxxviii. 352), it contains 35·36 S, and 64·64 Co, agreeing closely with the formula Co^2S.

The protosulphide may be prepared by throwing sulphur on red-hot cobalt contained in a retort, also by heating the protoxide with sulphur, and by igniting cobaltous sulphate to whiteness in a crucible lined with charcoal. As thus obtained, it is a grey laminar mass having the metallic lustre; according to Berthier, it is magnetic. In the wet way, it is produced by precipitating cobaltous acetate with sulphydric acid or any neutral cobaltous solution with an alkaline sulphide. The precipitate is a black powder which gives off water when heated, and in the moist state slowly oxidises in the air, being converted into sulphate. It is insoluble in alkalis and alkaline sulphides, soluble in concentrated mineral acids, insoluble or nearly so in dilute acids. It unites with acid sulphides, forming sulphur-salts, which are all insoluble in water. According to Anthon, it decomposes the solutions of other metals, *e. g.* iron, nickel, copper, and silver, a sulphide of the other metal being precipitated and the cobalt taking its place in the solution. This appears somewhat inconsistent with the action of dilute hydrochloric acid on a mixture of the sulphides of iron and cobalt, which, according to H. Rose (p. 1044), affords a method of completely separating cobalt from iron. It unites with peroxide of cobalt, forming an oxysulphide (*vid. sup.*).

Sesquisulphide of Cobalt, or *Cobaltic Sulphide*, is obtained by precipitating cobaltic acetate with sulphydric acid, or by heating cobaltic hydrate, but not to redness, in an atmosphere of the same gas. It has a dark grey colour. According to Fellenberg (Pogg. Ann. l. 73), it is obtained in graphitic laminæ by igniting the protoxide with sulphur and an alkali. *Linnæite* or *cobalt-pyrites* is commonly stated to be a sesquisulphide, but its composition approaches more nearly to that of the following compound.

Cobaltoso-cobaltic Sulphide, Co^3S^4, or $CoS.Co^2S^3$.—*Linnæite* from Müsen, near Siegren, in Prussia, has nearly this composition, yielding, according to Wernekink's analysis, 43·25 S, 53·35 Co, 0·97 Cu, and 2·30 Fe = 98·87, the formula requiring 42 S and 58 Co (Dana, ii. 66). In most varieties of this mineral, however, the cobalt is replaced to a greater extent by copper or nickel. (See LINNÆITE.)

Oxysulphide of cobalt heated in sulphydric acid gas yields a product which appears to be a sulphide intermediate in composition between the proto- and sesqui-sulphides. (Anthon.)

Disulphide of Cobalt, CoS^2, may be supposed to exist in combination with arsenide of cobalt in cobaltine (*q. v.*)

COBALT-BASES, AMMONIACAL. (F. Claudet [1857], Phil. Mag. [4] ii. 253.—Genth, Ann. Ch. Pharm. lxxx. 275.—Frémy, Ann. Ch. Phys. [3] xxxv. 257.—Rogojski, *ibid.* xli. 445.—Gregory, Ann. Ch. Pharm. lxxxvii. 125.—Gibbs and Genth, Smithsonian Contributions, 1856; Sill. Am. J. [2] xxxiii. 234, 319; xxxiv. 96; Ann. Ch. Pharm. civ. 150, 295; Jahresber, f. Chem. 1857, 227.—Künzel, J. pr. Chem. lxxii. 209).—Cobaltous salts treated with ammonia in a vessel protected from the air unite with the ammonia, forming compounds which may be called ammonio-cobaltous-salts. Most of them contain 6 at. ammonia to 1 at. of the cobalt-salt; thus the chloride contains $CoCl^2.6NH^3 + aq.$; the nitrate $Co(NO^3).6NH^3 + 2aq.$ They are generally crystallisable and of a rose-colour, soluble without decomposition in ammonia, but decomposed by water, with formation of a basic salt (Frémy). H. Rose, by treating dry chloride of cobalt with ammonia-gas, obtained the compound $CoCl^2.4NH^3$; and in like manner an ammonio-sulphate has been formed containing $CoSO^4.6NH^3$.

When an ammoniacal solution of cobalt is exposed to the air, oxygen is absorbed, the liquid turns brown (p. 1043), and new salts are formed containing a higher oxide of cobalt (Co^2O^3), and therefore designated generally as peroxidised ammonio-cobalt salts. Several of them containing different bases are often formed at the same time.

Most of the peroxidised ammonio-cobalt salts are composed of trisalts of cobalt (cobaltic salts), united with 2 or more molecules of ammonia. The composition of the neutral salts may be illustrated by the chlorides, as in the following table.

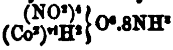
Tetrammonio-cobaltic chloride	$Co^2Cl^6.4NH^3$
Hexammonio-cobaltic chloride	$Co^2Cl^6.6NH^3$
Octammonio-cobaltic chloride	$Co^2Cl^6.8NH^3$
Decammonio-cobaltic chloride	$Co^2Cl^6.10NH^3$
Dodecammonio-cobaltic chloride . . .	$Co^2Cl^6.12NH^3$

The formulæ of the corresponding neutral nitrates are deduced from the preceding by substituting NO^3 for Cl; those of the sulphates, oxalates, and other bibasic salts, by substituting SO^4, C^2O^4, &c., for Cl^2. Thus, *decammonio-cobaltic sulphate* = $Co^2(SO^4)^3.10NH^3$. There are also several acid and basic salts of the same ammonio-molecules, the formulæ of which will be given further on. Further, there is a class of salts containing the elements of nitric oxide in addition to ammonia, *e.g. decammo-nitroso-cobaltic oxychloride* = $Co^2Cl^4O.10NH^3.2NO$. Lastly, Frémy has obtained ammoniacal compounds (oxycobaltic salts) containing salts of cobalt corresponding to the dioxide CoO^2.

TETRAMMONIO-COBALTIC SALTS.—The sulphite of this group is obtained by adding acid sulphite of ammonium to an aqueous solution of decammonio-cobaltic chloride containing a very small quantity of ammonia, till the odour of sulphurous acid becomes distinctly perceptible; on leaving the solution to stand for some time, the sulphite separates in brown, nearly insoluble octahedrons, containing $Co^2(SO^3)^3.4NH^3 + 5aq.$ (Künzel.)

HEXAMMONIO-COBALTIC SALTS.—When a solution of decammonio-cobaltic chloride containing a little ammonia, is mixed with so much acid sulphite of ammonium that the liquid does not smell either of ammonia or of sulphurous acid, it changes colour from red to deep yellow, and deposits *hexammonio-cobaltic sulphite*, $Co^2(SO^3)^3.6NH^3 + aq.$, as a yellow powder or in crystalline needles, according to the temperature and concentration of the liquid. It is insoluble in cold water, and is slowly decomposed by boiling with water. Its formation is expressed by the equation:

$$Co^2Cl^6.10NH^3 + 2NH^3 + H^2O + 6(NH^4.H.SO^3) =$$
$$[Co^2(SO^3)^3.6NH^3 + H^2O] + 6NH^4Cl + 3[(NH^4)^2.SO^3]. \text{ (Künzel.)}$$

OCTAMMONIO-COBALTIC SALTS. Frémy's *Fusco-cobaltic salts.*—These salts are formed when an ammoniacal solution of a cobaltous salt is exposed to the air, and by the action of water on oxy-cobaltic salts. They are brown, and mostly uncrystallisable, but may be obtained in the solid state by precipitation with alcohol or excess of ammonia. They are slowly decomposed by boiling with water, but quickly on addition of an alkali, with evolution of ammonia and precipitation of cobaltic hydrate. They are basic salts, the *nitrate* containing $Co^2O^3.2N^2O^5.8NH^3 + H^2O$ or  $\left.\begin{matrix}(NO^2)^4\\(Co^2)^{vi}H^2\end{matrix}\right\}O^8.8NH^3$, and the *hyposulphate* $Co^2O^3.2S^2O^5.8NH^3$.

Decammonio-cobaltic Salts. (Frémy, *loc. cit.*; Gibbs and Genth, *loc. cit.*)—These salts may be divided into two groups, the *Roseo-cobaltic salts*, which have a red colour, varying from brick to rose-red, and the *Purpureo-cobaltic salts*, which are purple, or violet-red. The salts of both groups contain 10 at. NH^3 to 2 at. cobalt, but the roseo-cobaltic salts are, for the most part, neutral, while the purpureo-cobaltic salts are either basic or acid; in some cases, however, as with the chlorides, the difference consists merely in the presence or absence of water, the purple salts being anhydrous, and the red hydrated.

The decammonio-cobaltic salts are produced by the direct oxidation of ammoniacal solutions of cobaltous salts, as when these solutions are exposed to the air, the red and purple salts being often produced together, the latter especially when the temperature is rather high, and the solution contains a free ammoniacal salt. The purpureo-cobaltic salts are likewise formed by the action of acids on xantho-cobaltic salts (p. 1054).

Decammonio-cobaltic salts are nearly insoluble in cold water, but soluble in warm water slightly acidulated; the purple salts are in general less soluble than the red. Their taste is purely saline, not metallic. When heated in the dry state, they decompose, giving off ammonia, and yielding an ammonium-salt and a cobaltous salt. Their aqueous solutions, when not acidulated, are decomposed by boiling, giving off ammonia and depositing a hydrated cobaltoso-cobaltic oxide. The solutions of roseo-cobaltic salts boiled with strong acids, are converted into purpureo-cobaltic salts.

Chlorides. 1. *Hydrated Decammonio-cobaltic chloride*, or *Roseo-cobaltic chloride*, $Co^2Cl^6.10NH^3 + 2aq$.—This salt was discovered by Claudet and by Genth, in 1851, being the first ammonio-cobaltic salt obtained; the formulæ originally assigned to it, however, gave a somewhat different view of its constitution. It is the most frequent product of the oxidation of an ammoniacal solution of protochloride of cobalt by exposure to the air, the liquid assuming first a brown, and then a red colour, and often, especially if the ammonia and the chloride of cobalt are impure, depositing a small quantity of cobaltic hydrate. The presence of sal-ammoniac in the solution does not facilitate its formation. The reddened solution mixed with strong hydrochloric acid, and carefully guarded against rise of temperature, deposits roseo-cobaltic chloride as a brick-red precipitate, which, after washing with strong hydrochloric acid, then with ice-cold water, and drying at the lowest possible temperature, contains $Co^2Cl^6.10NH^3 + 2H^2O$. It dissolves in water either cold or warm, with dark-red colour, which, however, changes after a while, especially if the solution be acidulated with hydrochloric acid and heated, to violet-red. The pure aqueous solution when boiled gives off ammonia and deposits hydrated cobaltoso-cobaltic oxide $Co^3O^4 + xH^2O$.

Roseo-cobaltic chloride forms double salts with the chlorides of the more electro-negative metals.

Purpureo-cobaltic chloride, $Co^2Cl^6.10NH^3$.—It has already been mentioned that the red solution of roseo-cobaltic chloride changes to violet when heated with hydrochloric acid. The same change takes place slowly in the dry salt. This purple modification is often formed, together with the red one and sometimes alone, during the oxidation of ammonio-cobaltous chloride, especially if the temperature is rather high, and the solution contains sal-ammoniac. By boiling the oxidised liquid with excess of hydrochloric acid, and crystallising the precipitated carmine-coloured powder from water acidulated with the same acid, the purpureo-cobaltic chloride is obtained pure. It may also be prepared by boiling a xantho-cobaltic salt (p. 1054),—the nitrate being best adapted for the purpose—with hydrochloric acid; lastly, by boiling any other purpureo-cobaltic salt with hydrochloric acid. It forms small violet-red or purple crystals, which, according to Dana, are dimetric combinations, P . ∞P∞ . P∞. Length of principal axis = 1·9016. P : P in the lateral edges = 114° 8′; in the terminal edges, 107° 12′. Specific gravity 1·802. The crystals are anhydrous, nearly insoluble in cold water, soluble without decomposition in boiling water slightly acidulated with hydrochloric acid. A larger addition of hydrochloric acid, or a solution of an alkaline chloride, precipitates it slowly in the cold, quickly on boiling. The solution yields with *tetrachloride of platinum* a brown-red precipitate, composed of flat microscopic needles, containing $Co^2Cl^6.10NH^3.2PtCl^4$.

Cyanides.—*Roseo-cobaltic cobalticyanide*, $(Co^2Cy^6.10NH^3).Co^2Cy^6 + 3H^2O$, is precipitated by cobalticyanide of potassium from roseo-cobaltic solutions, in cherry-coloured crystals apparently having the form of rhombic prisms, insoluble in cold water, decomposed by hot water. The *ferricyanide*, $(Co^2Cy^6.10NH^3).Fe^2Cy^6 + 3H^2O$, is an orange-coloured crystalline precipitate, possessing similar properties.

Oxides.—*Roseo-cobaltic oxide* is obtained in solution by decomposing the solution of the chloride with oxide of silver, or better—since chloride of silver is somewhat soluble in roseo-cobaltic chloride—by decomposing the sulphate with baryta-water.

The solution has an alkaline taste and reaction, absorbs carbonic acid from the air, and decomposes with facility.—*Purpureo-cobaltic oxide*, obtained in like manner, forms a violet-red alkaline solution, which absorbs carbonic acid from the air, and suffers decomposition when concentrated.

Nitrates.—The *neutral* or *roseo-cobaltic nitrate* is obtained, as a shining yellow precipitate, when an ammoniacal solution of cobaltous nitrate is left to oxidise in the air, (crystals of Frémy's oxycobaltic nitrate are frequently also formed at first, but subsequently disappear). The deep wine-red liquid yields, by spontaneous evaporation, red crystals, containing $Co^2(NO^3)^6.10NH^3. + 2H^2O$, easily soluble even in cold water. According to Dana, they are monoclinic combinations $\infty P\infty \,.\, (\infty P\infty) \,.\, +P\infty \,.\, -P\infty \,.\, \infty P$. Inclination of faces, $\infty P : \infty P$ in the clinodiagonal principal section = 103°; $\infty P\infty : +P\infty = 140° 30'$; $\infty P\infty : -P\infty = 136°$. From the solution of these crystals, or from the original oxidised ammoniacal solution, nitric acid added in the cold throws down a brick-red precipitate of the hydrated salt; but on boiling the liquid with nitric acid, the *anhydrous nitrate*, $Co^2(NO^3)^6.10NH^3$, is thrown down as a violet-red crystalline precipitate. It dissolves in dilute ammonia and separates from the solution by spontaneous evaporation in dimetric crystals $P \,.\, P\infty \,.\, \infty P \,.\, \infty P\infty \,.\, 3P3$. Inclination of $P : P$ in the lateral edges, = 82° 40′. This anhydrous salt is nearly insoluble in cold water, more soluble in hot water, but the solution is easily decomposed by heat; addition of nitric acid prevents the decomposition. The anhydrous salt explodes when heated, giving off nitrous vapours, and leaving black sesquioxide of cobalt.—A *basic nitrate*, probably $Co^2O^3.2N^2O^5.10NH^3 + 7H^2O$, or $\left.\begin{matrix}(NO^2)^4\\(Co^2)^{vi}H^2\end{matrix}\right\}O^6.10NH^3 + 6H^2O$, is obtained in purple scaly crystals, when a solution of the hydrated neutral nitrate, mixed with a large quantity of nitrate of ammonium and a little free ammonia is left to evaporate. These crystals are decomposed by solution in water, and when boiled with hydrochloric acid, yield, with brisk effervescence, a purple-red solution and a deposit of purpureo-cobaltic chloride (Gibbs and Genth). Both this basic nitrate and the anhydrous neutral nitrate appear to belong to the so-called purpureo-cobaltic group. Künzel, by exposing an ammoniacal solution of cobaltous nitrate to the air till it had acquired a dark olive-brown colour, and then adding nitrate of ammonium, obtained a yellow crystalline precipitate, to which he assigns the formula $2(Co^2O^3.10NH^3).5N^2O^5$.

Oxalates.—*Roseo-cobaltic oxalate* is precipitated by oxalate of ammonium from a solution of the chloride immediately, from the nitrate very slowly; it may be purified by recrystallisation from water containing ammonia. The cherry-coloured crystals, which are rhombic prisms of 101° 48′, with a brachydome of 108° 54′ contain $\left.\begin{matrix}(C^2O^2)^3\\(Co^2)^{vi}\end{matrix}\right\}O^6.10NH^3 + 6aq.$; they are nearly insoluble in pure water. The *basic*, or *purpureo-cobaltic oxalate*, $\left.\begin{matrix}(C^2O^2)^2\\(Co^2)^{vi}\end{matrix}\right\}O^5.5NH^3 + 3aq.$, separates in violet-red needles on adding oxalate of ammonium to a solution of purpureo-cobaltic chloride.

Oxalo-sulphates.—An *acid oxalo-sulphate*, $Co^2O^3.2C^2O^3.2SO^3.10NH^3 + 3aq.$ or $\left.\begin{matrix}(C^2O^2)^2\\(SO^2)^2\\(Co^2)^{vi}H^2\end{matrix}\right\}O^8.10NH^3 + 2H^2O$, is obtained in brick-red, ill-defined needles by boiling roseo-cobaltic sulphate for several hours with excess of oxalic acid. The solution of this salt assumes a violet-red colour on addition of ammonia, and, if exactly neutralised, yields by evaporation prismatic crystals of the *neutral oxalo-sulphate*, $\left.\begin{matrix}(C^2O^2)''\\(SO^2)''\\(Co^2)^{vi}\end{matrix}\right\}O^5.10NH^3 + 7H^2O$, which is more soluble than the acid salt and is easily decomposed by boiling.

Sulphates.—*Roseo-cobaltic sulphate* is generally (but not always) produced in an ammoniacal solution of cobaltous sulphate by atmospheric oxidation, the liquid becoming first brown and then dark red. On carefully adding sulphuric acid to this red solution, the sulphate is deposited as a brick-red crystalline powder, which may be purified by washing with cold water and recrystallisation from a slightly acidulated solution. The cherry-coloured crystals, containing $\left.\begin{matrix}(SO^2)^3\\(CO^2)^{vi}\end{matrix}\right\}O^6.10NH^3 + 5H^2O$, are, according to Dana, dimetric combinations, $P \,.\, 2P \,.\, P\infty \,.\, 0P \,.\, \infty P \,.\, \infty P\infty$. Inclination of $P : P$ in the terminal edges = 107° 20′. Length of principal axis = 1·0866. The salt is nearly insoluble in cold water, sparingly soluble in boiling water, and crystallises from the solution on cooling. It dissolves in dilute ammonia, and crystallises unaltered from the purple-red solution. On boiling the neutral salt, a dark brown powder separates, which, after drying in the air, contains $Co^2O^4 + 6H^2O$, while luteo-cobaltic sulphate remains in solution, being, however, partially decomposed.

An *acid* (*purpureo-cobaltic*) *sulphate*, $Co^2O^3.4SO^3.10NH^3 + 5H^2O$, or $\left.\begin{matrix}(\overset{''}{S}O^2)^4\\(Co^2)^{vi}.H^2\end{matrix}\right\}O^8.10NH^3 + 4H^2O$, is obtained by mixing the anhydrous chloride (p. 46) with oil of vitriol to a thick pulp, diluting the solution with twice its bulk of water, as soon as the evolution of hydrochloric acid has ceased, then washing the violet-red needles which separate with a little cold water, and pressing them; also by adding oil of vitriol to roseo-cobaltic sulphate till an oily liquid is produced; digesting this for an hour or two, taking care to avoid escape of oxygen, diluting the evolved purple solution with an equal bulk of water, and recrystallising. The crystals are red prisms; according to Dana, rhombic hemihedral combinations, $\infty P \,.\, \infty\breve{P}\infty \,.\, \frac{1}{2}\breve{P}\infty \,.\, \frac{\breve{P}2}{2} \,.\, \infty\breve{P}2$. Inclination of, $\infty P : \infty P = 106°$; $\frac{1}{2}\breve{P}\infty \;\; \frac{1}{2}\breve{P}\infty$, on the principal axis = 122° 42′. The salt has an acid taste and reaction, dissolves easily in water, but is quickly converted into the neutral (roseo-cobaltic) sulphate; especially by slow evaporation of a solution prepared with the aid of heat. (Gibbs and Genth.)

Sulphite. $\left.\begin{matrix}(\overset{''}{S}O)^3\\(Co^2)^{vi}\end{matrix}\right\}O^6.5NH^3 + \frac{2}{3}H^2O$.—Black-brown, heavy, amorphous precipitate, formed when sulphurous acid gas is passed through a dilute ammoniacal solution of decammonio-cobaltic chloride; also by passing the gas through water in which tri-ammonio-cobaltic sulphite (p. 45) is suspended. It is insoluble in cold water, and is decomposed by boiling water. (Künzel.)

NITROSO-DECAMMONIO-COBALTIC, or XANTHO-COBALTIC SALTS. (Gibbs and Genth, *loc. cit.*)—These salts are produced by passing the nitrous vapours evolved from a mixture of nitric acid and starch or sawdust, into ammoniacal solutions of cobaltous salts, or into neutral, acid, or ammoniacal solutions of roseo- or purpureo-cobaltic salts. The gas is absorbed; fumes of carbonate of ammonia make their appearance; the liquid gradually assumes a dark reddish-brown colour, and then, on cooling, generally deposits a xantho-cobaltic salt.

Xantho-cobaltic salts are brownish-yellow, more soluble in water than the roseo- or purpureo-cobaltic salts, the dilute solutions having a yellow, the more concentrated solutions a dark brown colour. They decompose, though not easily, when these solutions are boiled—sometimes also below the boiling temperature—giving off ammonia and depositing a dark-coloured heavy powder. The addition of a few drops of acetic acid prevents this decomposition; but, on adding a small quantity of an inorganic acid, nitric oxide gas is evolved, and a purpureo-cobaltic salt is formed, which, however, is difficult to separate from the undecomposed xantho-cobaltic salt.

The xantho-cobaltic salts appear to have the composition of trisalts of cobalt, associated with 10 at. NH^3, 1 at. N^2O^2, and 1 or 2 at. water.

The *chloride*, or rather *oxychloride*, $Co^2OCl^4.10NH^3.N^2O^2 + H^2O$, is not produced by either of the reactions just mentioned, but may be prepared by decomposing the sulphate with chloride of barium, and evaporating the filtrate at a gentle heat, after adding a few drops of acetic acid. It forms brownish-yellow, iridescent crystals. Its solution, mixed with *trichloride of gold*, yields a double salt, which, by recrystallisation from hot water, is obtained in brownish-yellow, iridescent prisms, containing $Co^2OCl^4.10NH^3.N^2O^2.2AuCl^3 + 2H^2O$.—The *chloroplatinate*, $Co^2OCl^4.10NH^3.N^2O^2.2PtCl^4 + 2H^2O$, is nearly insoluble in water, but may be crystallised from hot dilute hydrochloric acid. The *chloromercurate*, $Co^2OCl^4.10NH^3.N^2O^2.4HgCl^2 + 2H^2O$, is obtained by precipitation in pale brownish-yellow laminæ; by recrystallisation from hot slightly acidulated water, in brownish-yellow needles.

Xantho-cobaltic ferrocyanide, $Co^2OCy^4.10NH^3.N^2O^2.FeCy^2 + 7H^2O$, is obtained by precipitating the nitrate with ferrocyanide of potassium (the solutions of the chloride and sulphate are merely clouded by that reagent) in orange-yellow prismatic crystals, which give up their water easily and without decomposition, are insoluble in cold water, decomposed by hot water.

The *nitrate*, which is a basic salt, containing $Co^2O^3.2N^2O^5.10NH^3.N^2O^2 + H^2O$, or $\left.\begin{matrix}(NO^2)^4\\(Co^2)^{vi}H^2\end{matrix}\right\}O^6.10NH^3.N^2O^2$, forms light brownish-yellow, quadratic prisms, having P : P in the lateral edges between 100° 45′ and 101° 15′.

The *oxalate*, $Co^2O^3.2C^2O^3.10NH^3.N^2O^2 + 5H^2O = \left.\begin{matrix}(\overset{''}{C}{}^2O^2)^2\\(Co^2)^{vi}H^2\end{matrix}\right\}O^6.10NH^3.N^2O^2 + 4H^2O$, is obtained by precipitation in yellow acuminated crystals, insoluble in cold, sparingly soluble in boiling water, decomposed by boiling.

The *sulphate*, $Co^2O^3.2SO^3.10NH^3.N^2O^2 + H^2O$, or $\left\{\begin{matrix}(\overset{''}{S}O^2)^2\\(Co^2)^{vi}H^2\end{matrix}\right\}O^6.10NH^3.N^2O^2$, crystallises in thin plates, apparently rhombic. It dissolves in strong sulphuric acid, giving off but little nitric oxide, and forming a red oily liquid which gives off nitric oxide abundantly on addition of water, while the remaining liquid consists chiefly of ammonio-cobaltous sulphate, usually mixed with a small quantity of acid purpureo-cobaltic sulphate.

Dodecammonio-cobaltic, or Luteo-cobaltic Salts. **Frémy; Gibbs and Genth,** *loc. cit.*)—These salts, discovered by Frémy, are often produced by the direct oxidation of ammonio-cobaltous solutions; frequently also by the decomposition of pentammonio-cobaltic salts, although their molecule contains an additional atom of ammonia. They are of yellow or brownish-yellow colour, more soluble in water than the roseo-cobaltic salts, and yield brownish-yellow solutions. They are very permanent in presence of acids, but are decomposed by continued heating with sulphuric acid; in neutral or alkaline solutions they are easily decomposed by boiling.

Luteo-cobaltic chloride, $Co^2Cl^6.12NH^3$, is often formed during the oxidation, by exposure to the air, of an ammoniacal solution of dichloride of cobalt mixed with a large quantity of coarsely-pounded sal-ammoniac (in other cases, the products are roseo and purpureo-cobaltic chloride); almost always, if the ammoniacal solution contains sulphate of cobalt as well as chloride: in the latter case, a salt is formed containing sulphuric and hydrochloric acids, and this, when boiled with hydrochloric acid and chloride of barium, yields a solution of luteo-cobaltic chloride. This salt, purified by repeated crystallisation, forms brownish orange-coloured crystals of specific gravity 1·7016. They belong to the trimetric system, and, according to Dana, exhibit the faces $\infty P . 0P . \bar{P}\infty . 3\breve{P}\infty$, two faces, $\infty\bar{P}3$, on one side only of the macrodiagonal, and four faces. $\frac{3}{2}P$, lying in one zone. Inclination of $\infty P : \infty P = 113° 16'$. It dissolves easily in boiling water, and separates for the most part as the solution cools. It is precipitated unaltered by hydrochloric acid and the chlorides of the alkali-metals. Boiling aqueous ammonia decomposes it slowly, with formation of chloride of ammonium and a dark brown oxide of cobalt.

Concentrated solutions of luteo-cobaltic chloride and *tetrachloride of platinum* yield orange-coloured needles of a chloroplatinate containing $Co^2Cl^6.3PtCl^4.12NH^3 + 6aq.$; dilute solutions deposit yellow needles of the same compound with 21 at. water; these, according to Dana, are monoclinic combinations $\infty P . \infty P\infty . 0P$. Inclination of $\infty P : \infty P$, in the clinodiagonal section, $= 107° 10'$; $0P : \infty P\infty = 114° 15'$. The crystals are often twins united by the face 0P.—*Trichloride of gold* forms with luteo-cobaltic chloride a yellow precipitate, consisting of small granular crystals, $CoCl^6, 2AuCl^3.12NH^3$.

Luteo-cobaltic iodide, $Co^2I^6.12NH^3$, is thrown down by iodide of potassium from luteo-cobaltic solutions, as a yellow precipitate, nearly insoluble in cold water, moderately soluble in hot water, and separating in brownish-yellow crystals on evaporation. The bromide is obtained in like manner as a deep yellow precipitate, in other respects resembling the iodide.

Luteo-cobaltic Cobalticyanide, $(Co^2Cy^6.12NH^3).Co^2Cy^6 + H^2O$, is precipitated by cobalticyanide of potassium as a yellowish flesh-coloured precipitate composed of microscopic, oblique rhombic crystals. *Ferricyanide of potassium* forms an orange-yellow precipitate, exhibiting the same forms under the microscope.

Luteo-cobaltic Oxide.—By decomposing the sulphate with baryta-water, a brownish-yellow alkaline solution is formed, which absorbs carbonic acid from the air, and is decomposed by evaporation, with evolution of ammonia and deposition of a black powder.

Luteo-cobaltic Nitrate, $Co^2(NO^3)^6.12NH^3$, separates from an oxidised solution of ammonio-cobaltous nitrate in orange-coloured crystalline laminæ, the supernatant liquor being usually red and containing roseo-cobaltic nitrate. The salt, purified by recrystallisation, forms crystals belonging to the dimetric system, with the faces $P . 3P . 0P$. Angle of $P : P$ in the lateral edges $= 110° 20'$; of $3P : 3P$ in the same $= 153° 52'$. Length of principal axis for $P = 1·0161$.

Carbonates.—The *neutral carbonate*, probably $Co^2(CO^3)^3.12NH^3 + 7H^2O$, is obtained by decomposing a solution of the chloride with carbonate of silver, and leaving the liquid to evaporate in rhombic crystals, $\infty P . \infty\breve{P}\infty . \breve{P}\infty$. Inclination of $\infty P : \infty P = 116° 50'$; $\breve{P}\infty : \breve{P}\infty$ on the principal axis $= 114° 16'$. If the air has had access to the solution, the crystals are generally mixed with those of the acid salt. The *acid carbonate*, $(Co^2)^{vi}H^3C^4O^{12}.12NH^3 + 5aq.$, separates, on passing carbonic acid gas into the solution of the neutral salt, in large brown-red crystals, which, according to Dana, are monoclinic combinations, $\infty P . \infty P\infty . [\infty P\infty] . 0P . -P . +2P\infty$. Inclination of

$\infty P : \infty P$, in the clinodiagonal section, $= 85° 54'$; $0P : \infty P = 102° 20'$; $0P : \infty P\infty = 71° 44'$; $0P : -P = 139° 50'$; $\infty P : +2P\infty = 110° 46'$.

Oxalates.—The *neutral oxalate* is thrown down by oxalate of ammonia, as a reddish-yellow precipitate composed of slender needles, insoluble in water, easily soluble in oxalic acid, and separating therefrom in wine-yellow, efflorescent, prismatic crystals, containing $Co^2(C^2O^4)^3.12NH^3 + 4H^2O$. The *acid oxalate* was not obtained.

Luteo-cobaltic sulphate is obtained, mixed with the chloride, when an ammoniacal solution of cobaltous sulphate and chloride mixed with a large excess of coarsely pulverised sal-ammoniac, is left exposed to the air. The crystalline mass deposited at the bottom of the vessel is dissolved in hot water; the filtrate is acidulated with a few drops of sulphuric acid and treated with sulphate of silver; and the liquid, after filtration and concentration, is left to crystallise. The salt is also (though not constantly) produced by the action of strong ammonia on roseo-cobaltic sulphate, the change consisting simply in the assumption of 2 at. NH^3: also as a product of the decomposition of roseo-cobaltic sulphate (a salt of another base, not yet further examined, called by Genth and Gibbs *praseo-cobalt*, being sometimes formed simultaneously). The wine-yellow crystals of luteo-cobaltic sulphate contain $Co^2(SO^4)^3.12NH^3 + 5H^2O$, and give off 4 at. water in dry air, or in vacuo. According to Dana, they are trimetric combinations, $\infty P . 0P . \frac{2}{3}P . \frac{4}{3}P . 3\bar{P}\infty . \bar{P}\infty$; also with $3\breve{P}\infty$ or $\infty\breve{P}\frac{3}{2} . \bar{P}\infty . 3\breve{P}\infty$; also with $0P$ and $\breve{P}\infty$. Inclination of $\infty P : \infty P = 113° 38'$ and $66° 22'$; $\infty\breve{P}\frac{3}{2} : \infty\breve{P}\frac{3}{2} = 88° 44'$ and $91° 16'$; $\breve{P}\infty : \breve{P}\infty$, on the principal axis $= 112° 8'$; $\bar{P}\infty : \bar{P}\infty$, also on the same $= 88° 22'$; Luteo-cobaltic sulphate is isomorphous with the chloride, and the two salts are capable of crystallising together in all proportions.

Luteo-cobaltic chromate, obtained by precipitation (pure only from the nitrate), is yellow, soluble in hot water, and separates therefrom in yellow crystals. This salt also crystallises in all proportions with the chloride. (Gibbs and Genth.)

AMMONIO-PERCOBALTIC SALTS, or OXYCOBALTIC SALTS. Frémy (*loc. cit.*).—These salts contain 5 at. ammonia associated with a basic salt of dioxide of cobalt. Thus, the *nitrate* is $CoO^2.N^2O^5.5NH^3. + H^2O$, and the *sulphate*, $CoO^2.SO^3.5NH^3 + \frac{3}{2}H^2O$. They are produced by the action of the air on concentrated solutions of ammonio-cobaltous salts. They have generally an olive-brown colour; crystallise well, are but slightly soluble in the ammonial liquid, and are decomposed by water, especially when hot, with evolution of oxygen, liberation of ammonia, and separation of a green basic salt containing the oxide Co^3O^4. The nitrate of this group was first prepared, though not analysed, by L. Gmelin. (*Handbook*, v. 342.)

The oxycobaltic salts may be supposed to contain the diatomic base, CoO, thus:

$$\text{The } \textit{nitrate} = \left.\begin{matrix}(NO^2)^2 \\ (CoO)''\end{matrix}\right\} O^2.5NH^3.$$

$$\text{The } \textit{sulphate} = \left.\begin{matrix}(SO^2)'' \\ (CoO)''\end{matrix}\right\} O^2.5NH^3.$$

General formulæ of the Ammoniacal Cobalt-compounds.—These compounds may be represented as ammonium-salts, in which part of the hydrogen in one or more molecules of NH^4 is replaced by ammonium itself, and another portion, in the ammonio-cobaltous salts, by the diatomic radicle $Co'' = 59$; in the ammonio-cobaltic salts by the hexatomic radicle $Co^2 = 118$; and in the ammonio-percobaltic salts by the diatomic radicle $(CoO)'' = 75$. Such formulæ have been proposed by Weltzien (Ann. Ch. Pharm. xcvii. 19), and H. Schiff (Compt. rend. liii. 411).

In the following formulæ, which are nearly the same as those of Schiff, the symbol Am stands for NH^4 and X for a monatomic acid radicle, such as nitryl, NO^2.

α. Tetrammonio-cobaltous salts . . . . . $\left.\begin{matrix}N^2(Co''Am^2H^4 \\ X^2\end{matrix}\right\} O^2$

β. Hexammonio-cobaltous salts . . . . . $\left.\begin{matrix}N^2(Co''Am^4H^2 \\ X^2\end{matrix}\right\} O^2$

γ. Pentammonio-percobaltic (oxycobaltic) salts . $\left.\begin{matrix}N^3[CoO)''Am^3H^3] \\ X^3\end{matrix}\right\} O^4$

δ. Octammonio-cobaltic (fusco-cobaltic) salts . . $\left.\begin{matrix}N^6[(Co^2)^{vi}Am^2H^{16}] \\ X^4H^2\end{matrix}\right\} O^6$

ε. Decammonio-cobaltic salts:

Tetracid, or Purpureo-cobaltic . . . $\left.\begin{matrix}N^6[(Co^2)^{vi}Am^4H^{14} \\ X^4H^2\end{matrix}\right\} O^6$

Hexacid, or Roseo-cobaltic . . . . $\left.\begin{matrix}N^6[(Co^2)^{vi}Am^4H^{14} \\ X^6\end{matrix}\right\} O^6$

ζ. Xantho-cobaltic salts . . . . . . $\left.\begin{matrix}N^6[(Co^2)^{vi}Am^4H^{12}(NO)^2] \\ X^4H^2\end{matrix}\right\} O^6$

η. Dodecammonio-cobaltic (luteo-cobaltic) salts . $\left.\begin{matrix}N^6[(Co^2)^{vi}Am^6H^{12}) \\ X^6\end{matrix}\right\} O^6$

Some of these formulæ, viz. those of the fusco-, purpureo-, and xantho-cobaltic salts differ by 2 at. H from those previously given; but in compounds of such complexity the question of a molecule of hydrogen more or less can scarcely be decided by analysis.

The formulæ of the chlorides and oxychlorides are deduced from those in the table by substituting 1 or more at Cl for a corresponding number of atoms of XO.

The salts β are transformed, by the joint action of ammonia and oxygen into γ, and these, by further oxidation, are resolved into ammonia and the salts δ, which again, by addition of 2 at. NH^3 are transformed into ϵ; and these last by the further action of ammonia, yield η. The salt ζ are formed by the action of nitrous acid on ϵ, and are reconverted into the tetracid salts ϵ, with evolution of nitric oxide, by the action of strong acids.

For Weltzien's formulæ, see *Graham's Elements of Chemistry*, 2nd edition, ii. 721. Gibbs and Genth object to the representation of these compounds as ammonium-salts, and express their composition by means of formulæ involving so-called conjugate radicles, such as $6NH^3.Co^2$ in the luteo-cobaltic salts, and $NO.5NH^3.Co^2$, in the xanthocobaltic salts. It is not easy to say what is gained by such a mode of representation.

COBALT-BLOOM. *Erythrine, Prismatic Red Cobalt, Red Cobalt-Ochre, Cobalt-mica, Kobalt-blüthe.*—A hydrated arsenate of cobalt, $Co^3As^2O^8 + 4H^2O$, or $3CoO.As^2O^5 + 8H^2O$, occurring in monoclinic crystals, in which the orthodiagonal, clinodiagonal, and principal axis are as 1·3818 : 1 : 0·9747. Inclination of clinodiagonal to principal axis = 70° 54′; $\infty P : \infty P = 111° 16'$. Observed faces $+ P\infty . + P . [\infty P\infty] . [\infty P\frac{4}{3}] . \infty P\frac{3}{2} . \infty P\infty$ sometimes with $+ 3P\infty$ and $+\frac{3}{2}P\infty$ between $\infty P\infty$ and $+P\infty$. The faces $\infty P\infty$ and $+ P\infty$ are vertically striated. It is likewise found in globular and vermiform masses; also pulverulent, incrusting. Specific gravity = 2·948. Hardness, 1·5—2·5, least on $[\infty P\infty]$. Lustre on $[\infty P\infty]$ pearly; on the other faces, adamantine inclining to vitreous. Colour, red of various shades, grey and green, the red tints incline to blue when viewed at right angles to cleavage. Streak, peach-blossom red. Sectile. Flexible in thin plates.

Analyses of cobalt-bloom from Schneeberg by Karsten (Pogg. Ann. lx. 251), gave

As^2O^5	CoO	FeO	CaO	H^2O		
38·43	36·52	1·01	—	24·10	=	100·06
38·30	33·42	4·01	—	24·08	=	99·81
38·10	29·19	—	8·00	23·90	=	99·19

The formula requires 38·43 As^2O^5, 37·53 CoO, and 24·02 water.

The mineral, when heated in a tube, yields water and turns blue if pure, green if it contains nickel or iron. Before the blowpipe, on charcoal, it gives an arsenical odour and melts in the inner flame to a dark grey bead of arsenical cobalt; gives with fluxes the usual cobalt reaction. Dissolves easily in acids.

Earthy cobalt-bloom (*Kobalt-beschlag*), of peach-blossom colour, is arsenate of cobalt with free arsenious acid. A specimen from Schneeberg analysed by Karsten gave 51·00 per cent. As^2O^3, 19·10 As^2O^5, 16·60 CoO, 2·10 FeO, and 11·90 water (= 100·70), with traces of nickel, lime, and sulphuric acid.

Cobalt-bloom occurs in minute crystals at Schneeberg in Saxony, Saalfeld in Thuringia, Riechelsdorf in Hessia, Wolfach and Wittichen in Baden, and Modum in Norway. The earthy varieties are found in Dauphiny, in Cornwall, and near Alston, Cumberland. A green variety occurs at Platten in Bohemia. The mineral is also found at Prince's mine, Lake Superior, in calcite. When abundant, it is used for the manufacture of smalt. (Dana, ii. 407.)

COBALT-BLUE. A pigment of a fine blue colour, like that of ultramarine, obtained by mixing the solution of a cobalt-salt, perfectly free from iron and nickel, with a solution of pure alum, precipitating with an alkaline carbonate, carefully washing the precipitate, then drying and igniting it strongly. It is a compound of protoxide of cobalt and alumina, and is used both as oi and water colour.

COBALT-GLANCE. See COBALTINE.

COBALT-GREEN. *Rinman's Green.*—A permanent green pigment prepared by precipitating a mixture of the sulphates of zinc and cobalt with carbonate of sodium, and igniting the precipitate after thorough washing;—or by mixing a solution of nitrate of cobalt with oxide or nitrate of zinc, then evaporating and igniting.

COBALTINE. *Cobalt-glance, Glance-cobalt, Silver-white cobalt, Cobalt gris.*—A native sulpharsenide of cobalt, $Co^2As^2S^2$ or $CoAs^2.CoS^2$, occurring in forms of the regular system, viz. the cube, octahedron, pentagonal dodecahedron, and several combinations of these forms. Cleavage parallel to the cubic faces. Also massive, granular or compact. Specific gravity = 6—6·3. Hardness = 5·5. Fracture imperfect, conchoïdal, uneven. Opaque, with metallic lustre. Colour silver-white, inclining to copper-red, occasionally tarnished. Streak, greyish-black. Brittle.

Before the blowpipe, it gives off fumes of arsenic, and yields, after roasting, a dull black feebly magnetic globule, which colours borax blue. It dissolves in warm nitric acid, leaving a residue of arsenious acid.

Analyses.—*a*, from Skutterud by Stromeyer; *b*, from Siegen by Schnabel; *c*, from Orowitza in the Banat by Huberdt; *d*, from the same by Patera; *e*, from Skutterud by Ebbinghaus; *f*, from Siegen by Schnabel. (*Rammelsberg's Mineralchemie*, p. 60.)

	Co	Fe	As	Sb	S	
a . .	33·10	3·23	43·46	. .	20·08	= 99·88
b . .	29·77	6·38	44·75	. .	19·10	= 100·00
c . .	30·37	5·75	44·13	. .	19·75	= 100·00
d . .	32·03	4·56	43·63	. .	19·78	= 100·00
e . .	32·60	3·47	43·68	. .	20·58	= 100·34
f . .	8·67	25·98	42·53	2·84	19·98	= 100·00

The formula $Co^2As^2S^2$ requires 35·5 Co, 45·2 As, and 19·3 S. In analysis *f*, three-fourths of the cobalt is replaced by iron.

Cobaltine occurs in large splendid crystals at Tunaberg, Riddarhyttan, and Hokansbö in Sweden, and at Skutterud in Norway. It is also found at Querbach in Silesia, Siegen in Westphalia, and several localities in Cornwall. This species and smaltine afford the greatest part of the smalt of commerce. The most productive mines are those of Vena in Sweden. (Dana, ii. 58.)

COBALT-MICA. Syn. with COBALT-BLOOM.

COBALT-PYRITES. See COBALT, SULPHIDES OF (p. 1050).

COBALT-VITRIOL. *Bieberite, Red Cobalt, Rhodalose.*—Hydrated native sulphate of cobalt, of somewhat variable constitution, found in stalactites, and crusts investing other minerals, in the rubbish of old mines at Bieber near Hanau, and at Leogang in Salzburg. It is translucent, with flesh-red or rose-red colour and vitreous lustre. A specimen analysed by Winkelblech (Ann. Ch. Pharm. xiii. 265), after being freed by solution and filtration from admixed manganous arsenate, yielded 29·05 SO^3, 19·91 CoO, 3·87 MgO and 46·83 water, agreeing nearly with the formula $(Co^3Mg).(SO^4)^4 + 28\ aq.$

COBALT-YELLOW. This compound, discovered by Saint-Èvre in 1852 (Ann. Ch. Phys. [3] xxxviii. 177), and further examined by A. Stromeyer (Ann. Ch. Pharm. xcvi. 218), is produced by the action of nitrite of potassium on cobaltous salts. Saint-Èvre regards it as a compound of peroxide of nitrogen with cobaltous oxide and potash, $CoO.K^2O.2N^2O^4$ or $CoK^2O^2(NO^2)^4$:

$$\underset{\text{Nitrate of cobalt.}}{Co(NO^3)^2} + \underset{\text{Nitric acid.}}{4HNO^3} + \underset{\text{Nitrite of potassium.}}{8KNO^2} = \underset{\text{Cobalt-yellow.}}{CoK^2O^2(NO^2)^4} + \underset{\text{Nitrate of potassium.}}{6KNO^3} + \underset{\text{Nitric oxide.}}{2N^2O^2} + 2H^2O.$$

Stromeyer, on the other hand, regards it as a basic potassio-cobaltic nitrite,

$Co^2O^3.3K^2O.5N^2O^3$ or $\left.\begin{matrix}(NO)^{10}\\ (Co^2)^{vi}.K^6\end{matrix}\right\}O^{11}$, on which supposition its formation may be represented by the equation:

$$\underset{\text{Nitrate of cobalt.}}{2\left(\left.\begin{matrix}(NO^2)^2\\ Co''\end{matrix}\right\}O^2\right)} + \underset{\text{Nitrite of potassium.}}{10\left(\left.\begin{matrix}NO\\ K\end{matrix}\right\}O\right)} + O = \underset{\text{Cobalt-yellow.}}{\left.\begin{matrix}(NO)^{10}\\ (Co^2)^{vi}.K^6\end{matrix}\right\}O^{11}} + \underset{\text{Nitrate of potassium.}}{4\left(\left.\begin{matrix}NO^2\\ K\end{matrix}\right\}O\right)}$$

The compound is prepared: 1. By adding an alkaline solution of nitrite of potassium (obtained by passing the nitrous vapours evolved from a mixture of nitrate of potassium and starch into caustic potash) to an acid solution of nitrate of cobalt.—2. By adding potash, not in excess, to a solution of nitrate of cobalt, so as to throw down a blue basic salt (p. 1043), treating this with a slight excess of nitrite of potassium, and adding nitric acid in a thin stream from a pipette.—3. By treating nitrate of cobalt with a slight excess of potash, so as to throw down the rose-coloured hydrate, and passing nitric oxide gas into the mixture.—It forms a bright yellow crystalline powder composed of microscopic four-sided needles with pyramidal summits. It is insoluble in cold water, also in alcohol and ether, but when boiled with water, it gradually dissolves, with evolution of acid vapours, and the solution, if subsequently evaporated, yields a lemon-yellow salt of different composition. Nitric acid and hydrochloric acid do not act upon it in the cold, but decompose it at the boiling heat, with evolution of nitrous vapours. Sulphydric acid decomposes it very slowly, sulphide of ammonium immediately forming black sulphide of cobalt; when heated, it assumes an orange-yellow colour, gives off water and afterwards nitrous fumes, and leaves sesquioxide of cobalt mixed with nitrate of potassium.

Cobalt-yellow forms an excellent pigment for artistic purposes, having a beautiful colour, like that of sulphide of cadmium, great permanence, and mixing easily with other colours. Its formation affords also an excellent method of separating cobalt from other metals, especially from nickel (p. 1046).

When a solution of lead is mixed with nitrite of potassium and acetic acid, the liquid assumes a yellow colour, but no precipitation takes place; but on adding a cobalt-salt, a yellowish-green precipitate (brownish-black and crystalline from dilute solutions) is formed, whose composition is that of the yellow cobalt-compound, having half the potassium replaced by lead. (Stromeyer.)

COCA. The leaves of *Erythroxylon Coca*, a plant cultivated in the mountainous districts of Peru and Bolivia, and in some parts of Brazil, are extensively used by the inhabitants of those countries, and of other parts of South America, for chewing like tobacco, for which purpose they are mixed with burnt lime, or the ash of a peculiar plant, the *Chenopodium Quinoa*, according to Niemann. They possess powerful tonic and sedative properties, and the practice of chewing them is said to give great power of enduring fatigue, even on a scanty supply of food; but like the use of opium, it is apt to become an indispensable necessity, and ultimately produces all the baneful effects of a narcotic poison, such as hallucinations and premature decay both of body and of mind. The use of coca is said to prevail among ten millions of people in South America, the annual consumption amounting to thirty million pounds of the dry leaves. Coca leaves do not long retain their activity; indeed they are said to become useless after a year's keeping.

Coca leaves contain, according to Niemann (Arch. Pharm. [2] ciii. 120 and 291), a crystallisable basic substance called cocaïne, a volatile odoriferous substance, a peculiar tannic acid, cocatannic acid, and a waxy body, coca-wax.

The volatile constituent of coca leaves has a strong tarry, almost intoxicating odour. On distilling the leaves with water a slightly turbid distillate is obtained, from which no oil separates; but on saturating it with common salt and redistilling, a very small quantity of a white non-crystalline substance is obtained, which is volatile, fusible, lighter than water, and possesses in a very high degree the odour of the leaves.

Cocatannic acid remains in the aqueous decoction of the leaves after the cocaïne has been precipitated by carbonate of sodium, and is left as a brown-red amorphous substance when the liquid is evaporated. Its solution is coloured deep brownish-green by ferric chloride, and is precipitated by tartar emetic, or solution of white of egg, but not by gelatin; it reduces chloride of gold even in the cold.

Coca-wax is contained in the precipitate formed by lime in extract of coca leaves prepared with alcoholic sulphuric acid. It contains 80·2 per cent. carbon and 13·4 hydrogen, agreeing with the formula $C^{33}H^{66}O^{2}$, and with the composition of the wax from grass, and of that from *Syringa*, as determined by Mulder. If the precipitate be exhausted with ether, the ether evaporated, and the residue repeatedly boiled with alcohol, the solution on cooling deposits a wax, which is white, amorphous, very friable, and becomes strongly electric by trituration. It is insoluble in water, dissolves slowly in boiling alcohol, easily in ether, sometimes, though rarely, remaining in a somewhat crystalline form when the ethereal solution is evaporated. It melts at 70° C., and decomposes when heated. Aqueous alkalis do not act upon it, but melting hydrate of potassium decomposes and dissolves it.

The substance mixed with coca leaves, to render them fit for chewing, is called *Llipta*. According to Niemann, it is the ash of *Chenopodium Quinoa*. Gädeke found it in 40·0 $K^{2}O$, 17·7 $Na^{2}O$, 5·6 MgO, 0·2 Fe, 4·5 $P^{2}O^{5}$, 1·8 SO^{3}, 2·5 Cl, 6·7 SiO^{2}, 3·0 CO^{2}, 13·5 sand, 1·0 water, and a trace of organic matter. (Handw. d. Chem. ii. [2] 123.)

COCAÏNE. $C^{16}H^{19}NO^{4}$ or $C^{32}H^{19}NO^{8}$. (Niemann, Ann. Ch. Pharm. cxiv. 213.) —An alkaloïd obtained from coca leaves, resembling atropine in many of its properties. Niemann assigns to it the formula $C^{32}H^{20}NO^{8}$; but this is improbable, because the sum of the atoms of H and N is an odd number.

Cocaïne is prepared by digesting coca leaves with 85 per cent. alcohol containing a small quantity of sulphuric acid, mixing the expressed mass with milk of lime, neutralising the filtrate with sulphuric acid, evaporating off the alcohol, mixing the residue with water, precipitating the resulting yellow-brown solution with carbonate of sodium, treating the brown precipitate of impure cocaïne with ether, and evaporating. Cocaïne then remains, partly amorphous, partly crystalline, and may be purified by repeated treatment with alcohol.

Cocaïne crystallises in small, colourless, inodorous prisms; it has a slightly bitter taste, and produces temporary insensibility on the part of the tongue with which it comes in contact. It is soluble in 704 pts. of water at 12° C., more soluble in alcohol, and still more in ether. It melts at 98° C., and solidifies to a transparent mass, which gradually becomes white and crystalline. At a higher temperature, a very small portion appears to volatilise undecomposed, but the greater part is decomposed, yielding ammoniacal products. Cocaïne dissolves without colour in strong nitric, hydrochloric, and sulphuric acid, the last solution only becoming black when heated.

Cocaïne is strongly alkaline; it dissolves in dilute acids, and neutralises them completely. Its salts do not crystallise readily, the hydrochlorate, however, more easily than the others. Solutions of cocaïne-salts yield with *caustic alkalis*, a white precipitate soluble only in a large excess of fixed alkali, more soluble in ammonia. *Carbonate of sodium* forms a precipitate insoluble in excess. *Carbonate of ammonium* a precipitate easily soluble in excess. *Acid carbonate of potassium* and *phosphate of sodium* produce a red precipitate. *Sulphocyanide of potassium* produces but a slight turbidity; *picric acid* forms a sulphur-yellow precipitate, which gradually aggregates into resinous lumps; *tannic acid*, on addition of hydrochloric acid, forms a white precipitate, which aggregates in a similar manner; *mercuric chloride* and *potassio-mercuric iodide* produces white precipitates; *iodine-water* a kermes-brown; *iodide of potassium* containing iodine, a dark-brown precipitate; *trichloride of gold* and *dichloride of platinum* yield precipitates with the hydrochlorate; *protochloride of tin* produces a white precipitate, even in slightly acid and dilute solutions.

In most of these reactions, cocaïne closely resembles atropine (i. 474); the latter, however, is not precipitated by carbonate of ammonia, or in acid solutions by stannous chloride; the two bases differ also in their reactions with gold and platinum-salts, and in their melting points, that of cocaïne being 6° C. higher than that of atropine.

Hydrochlorate of Cocaïne crystallises in white slender needles, easily soluble in water; it has a bitter taste and produces on the tongue the peculiar action of the base itself, but in a higher degree. The solution, even when very dilute, is precipitated by *chloride of gold*, yielding the compound $C^{16}H^{19}NO^4.HCl.AuCl^3$, which crystallises from alcohol in gold-yellow scales or laminæ. This gold-salt melts when heated, and then yields a sublimate of benzoic acid, affording a very characteristic reaction. The *chloroplatinate* is a yellow-brown flocculent precipitate, which soon becomes crystalline, and is nearly insoluble in hydrochloric acid.

Acetate of Cocaïne crystallises readily; the *nitrate* with difficulty. The *sulphate* remains when its solution is evaporated, as a colourless varnish-like mass, which becomes crystalline after a while; it is permanent in the air.

COCATANNIC ACID.—COCA-WAX. See Coca (p. 1059).

COCCIN. A peculiar nitrogenous substance existing, according to Pelletier and Caventou, in cochineal, and forming, as it were, the flesh of the insect; it resembles gelatin in some of its characters, albumin and fibrin in others.

COCCINITE. Haidinger's name for the reddish-brown mineral, with adamantine lustre, from Casas Viejas in Mexico, which Del Rio regards as mercuric iodide. It melts and sublimes with facility.

COCCINNIC ACID. A volatile fatty acid existing, according to Pelletier and Caventou, in cochineal.

COCCINONIC ACID. A derivative of euxanthic acid (p. 712).

COCCODEA VIRIDIS. This plant contains a green colouring matter differing from chlorophyll. (Salm-Horstmar, Pogg. Ann. xciv. 466; cxv. 176.)

COCCOGNIC ACID. An acid contained, according to Göbel (Buchn. Repert. viii. 203), in the seeds of *Daphne Gnidium*. It is dissolved by water from the alcoholic extract; crystallises in colourless, slightly acid prisms; does not precipitate lime-water, or the solutions of chloride of barium, acetate of lead, or ferrous sulphate.

COCCOLITE. A name applied to certain granular varieties of augite.

COCCOLOBA UVIFERA. The plant which yields American kino.

COCCULIN. Syn. with Picrotoxin.

COCCULUS INDICUS. *Grains of Paradise.*—The fruit of the *Cocculus suberosus* (Dec.), *Menispermum cocculus* (Linn.), *Anamirta cocculus* (Wight and Arnott). It possesses strong narcotic and poisonous properties, due to the presence of a bitter substance, picrotoxin ($C^6H^6O^2$), of which it contains about $\frac{1}{50}$ of its weight. It is used to adulterate beer, and is sometimes thrown into water to intoxicate or kill fish; it is occasionally employed in medicine. (See *Ure's Dictionary of Arts, Manufactures and Mines*, i. 786; also the article Beer in this Dictionary, i. 537.)

COCCUSIC ACID, $C^8H^6O^8$, is the acid corresponding to nitrococcusic acid, a product of the action of nitric acid on carmine (i. 804); it has not yet been obtained in the separate state.

COCHINEAL. *Cochenille, Coccionella.*—Several insects of the genus *Coccus*, especially the *Coccus cacti* or cochineal insect, yield a splendid colouring matter, extra-sively used for dyeing and the preparation of pigments. The cochineal insect lives on various plants of the genus *Opuntia*, especially on the nopal, *Opuntia decumana*, *O. cactus*, and *O. monacantha*. It is a native of Mexico, but its cultivation has been introduced into many other hot countries, namely, the West Indies, Teneriffe, Madeira, Algeria, Java: in colder climates it does not thrive. The female insects only are collected; they are killed either by drying in the sun, on hot plates, or in stoves, or by immersing them for a short time in hot water. The last method yields a cochineal of somewhat red-brown aspect, whereas if the insects have been killed by drying, it has more of a blackish or ash-grey colour, with a silvery surface; the latter is preferred. The dry cochineal is freed from dust and adhering impurity by shaking it in sacks; the fine dust is then removed by sifting, and the larger and smaller lumps in the remaining mass are separately sorted.

Other species of coccus probably contain the same colouring matter, but in smaller quantity and more contaminated with foreign substances.

Cochineal occurs in commerce in nearly egg-shaped grains 1 or 2 lines long, somewhat hollowed below and arched above, about 70,000 going to the pound. It is inodorous, very friable, and contains within it a dark red granular mass, which yields a powder of a fine deep red colour; it has a bitter, slightly astringent taste, and leaves but a small quantity of ash when burnt. In water, it swells up considerably, the shape of the insect and its three pairs of legs then becoming distinctly visible.

The first investigation of cochineal was made by John (*Chemical Tables*, p. 127), who found in it 50 per cent. coccus-red (carmine), 10 waxy fat, 1·5 inorganic salts (chlorides of potassium and ammonium, and phosphates of calcium, iron, and magnesium), 28·0 animal matter, and 10·5 water. According to Pelletier and Caventou (Ann. Ch. Phys. vii. 90; viii. 255), it contains a peculiar nitrogenous matter, coccin (p. 54), which forms, as it were, the flesh of the insect, and an acid, not examined, to which they give the name of coccinic acid.

The colouring matter of cochineal is carminic acid (i. 804).

The watery extract likewise contains a crystallisable nitrogenous substance, $C^9H^{11}NO^3$, homologous with tyrosine, ($C^8H^9NO^3$), and very similar to it in appearance and reactions. It remains in the aqueous decoction of cochineal after the carminic acid has been precipitated by acidulated acetate of lead, and may be separated by removing the excess of lead from the filtrate with sulphuretted hydrogen, and evaporating to a syrup; it then separates in a crystalline mass, and an additional quantity may be obtained by further concentration. It is insoluble in alcohol and ether, soluble without decomposition in hydrochloric acid, decomposed by strong nitric acid, the liquid yielding crystals of a new acid on evaporation; hot nitric acid produces a more thorough decomposition, with separation of charcoal. The chalky substance dissolves in alkalis, and is separated therefrom by acids. It does not appear to form definite compounds either with acids or with bases.

The mother-liquor from which the whole of the chalky substance has been removed, dries up to a soft mass amounting to 10 or 12 per cent. of the cochineal; part of this mass is soluble in alcohol, the remainder in water.

Cochineal boiled with water yields a deep red liquid, which assumes a reddish-yellow colour when mixed with *tincture of galls* or with strong *acids*, and a beautiful violet with *lime-water*; it is precipitated violet-blue by *neutral acetate of lead*, bright red by *ammonia*, dark black-brown by *ferric chloride*; olive-green by a larger quantity, deep red by *alum*. After the cochineal has been thoroughly boiled with water, a brownish animal substance remains.

The red colour of cochineal is likewise extracted by alcohol.

The chief use of cochineal is for the preparation of carmine and carmine-lakes (i. 804). It is likewise employed for dyeing wool and silk scarlet (the fabric being steeped first in annotto, then in a decoction of cochineal containing cream of tartar and stannoso-stannic chloride), or crimson (cochineal with tartar and tin-salt). Cochineal is likewise used for the preparation of rouge, of painters' colours, and of red ink, and for colouring tooth-powder, confectionery, liqueurs, &c.

Cochineal varies much in colouring power, according to its source and mode of preparation. The relative quantities of colouring matter in different samples may be estimated approximately by the depth of colour of a solution obtained by heating 1 gramme of cochineal in the water-bath for an hour, with 1000 grammes of water and 20 drops of a saturated solution of alum; also by the depth of colour which the same extract will impart to wool. Robiquet estimated the amount of colouring matter by means of a graduated solution of chlorine; Anthon by a graduated solution of an alumina-salt.

A better method is that of Penny, depending on the action of ferricyanide of potassium. 1 gramme of cochineal is extracted with 50 cub. cent. of dilute potash-solution; the extract is further diluted with 100 cc. of cold water; and the purple solution thereby obtained is mixed, when cold, with a graduated solution of ferricyanide of potassium (1 grm. of the salt to 200 cc. of solution), till its colour changes to dark brown. All these methods yield only relative results for comparing different sorts of cochineal one with the other. (See *Ure's Dictionary of Arts, Manufactures and Mines*, i. 786; Handw. d. Chem. 2te Aufl. ii. [2] 127.)

COCHINEAL-RED is properly carmine; the same term is, however, applied to a splendid red artificial colour, which contains a considerable quantity of arsenate of aluminium, and is therefore highly poisonous.

COCHLEARIA. A genus of cruciferous plants, including horse-radish and scurvy-grass, distinguished by their acridity, arising from the presence of volatile oils, similar to, or identical with, volatile oil of mustard (sulphocyanate of allyl).

Cochlearia Armoracia. Horse-radish.—The volatile oil of this plant, when purified, is identical with oil of mustard. It appears to exist in the root ready formed, and may be obtained by bruising the root to a pulp, and distilling it *per se*. The best mode of preparation, however, is to distil 3 pts. of the finely chopped root with 2 pts. water, in a glass vessel (if a copper still be used, only a small quantity of oil is obtained, in consequence of the formation of metallic sulphide). 100 pts. of the root thus treated yield about 0·05 pt. of crude oil, which may be purified by rectification with water and drying over chloride of calcium. The purified oil is colourless or pale yellow; has a density of 1·01; smells like oil of mustard, and contains 48·41 per. cent. C, and 5·26 H (sulphocyanate of allyl, C^3H^5.CNS, requires 48·49 C and 5·05 H). The crude oil is light yellow, of the consistence of cinnamon-oil, heavier than water, evaporates quickly, has an intolerable odour of horse-radish, tastes sweet at first, afterwards sharp and burning, and inflames the lips and tongue. When kept under water for a year, it disappears, and silvery needles are formed, which smell like horse-radish, excite irritation in the throat, melt and volatilise when heated, and dissolve but slowly in alcohol. Oil of horse-radish is decomposed by nitric acid, sulphuric acid, and chlorine. It yields sinapoline with oxide of lead, and thiosinnamine with ammonia. It dissolves slightly in water, the solution forming a brown precipitate with acetate of lead, black with nitrate of silver. It dissolves readily in alcohol (Gm. x. 55).

Cochlearia officinalis. Common scurvy grass.—The herb of this plant contains 92·2 per cent. water, and yields 1·6 per cent. ash, which, according to Geiseler, is very rich in potash, but, according to Braconnot, contains soda. The base is partly combined with nitric acid and, according to Braconnot, with an organic acid resembling malic acid.

Oil of scurvy-grass, *Oleum cochleariæ*, obtained by distilling the herb with water, is yellow, pungent, of specific gravity 0·942 (Geiseler), boils between 156° and 159° C. (Simon). It dissolves easily in alcohol, and the alcoholic solution, *Spiritus cochleariæ*, may be obtained by distilling the bruised herb with alcohol. According to Geiseler (Arch. Pharm. cxlvii. 136, 257), the oil is an oxysulphide of allyl, C^6H^5SO, and yields with ammonia a crystalline compound, $C^6H^5SO.NH^3$. [These formulæ are doubtful.] The oil does not exist ready formed in the plant, but is produced by the action of myrosin in presence of water, on a peculiar substance existing therein. According to Winckler (Jahrb. pr. Pharm. xviii. 319), this substance is neutral, and is converted into the volatile oil by the joint action of myrosin and lime.

Scurvy-grass camphor, or Cochlearin, $C^6H^{14}O^2$(?), is a crystalline substance sometimes deposited from *Spiritus cochleariæ*, and from the water which has been distilled off the plant. It forms small, nacreous, shining laminæ or needles, having a faint odour, and sharp aromatic taste. Specific gravity = 1·248. It melts at 45° C., sublimes without alteration, dissolves lightly in pure water, easily in water containing carbonate of potassium, also in alcohol and ether. (Maurach, Repert. Pharm. xcix. 128.)

Cochlearia Draba, Whitlow Pepperwort, yields, by distillation with water, a volatile oil, similar to that obtained from radish-seeds. (Pless, Ann. Ch. Pharm. lviii. 40.)

Cochlearia anglica. English scurvy-grass.—The fresh herb of this plant contains, according to T. J. Herapath (Chem. Soc. Qu. J. ii. 4), 2·42 per cent. ash; the dry herb 21·1 per cent. ash; of which 78·1 per cent. are soluble, and 21·9 per cent. insoluble in water. 100 parts of the ash contain:

Soluble in Water.		*Insoluble in Water.*	
Potash	0·1	Carbonate of calcium	7·2
Soda	7·7	Carbonate of magnesium	1·3
Carbonic anhydride	3·6	Phosphate of calcium	10·3
Sulphuric anhydride	3·1	Ferric phosphate	0·6
Chloride of sodium	63·6	Silica	2·5

COCHLEARIN. See COCHLEARIA OFFICINALIS.

COCINIC ACID. *Cocostearic acid. Cocylic acid. Coconustalgsäure.*—A fatty acid, or probably a mixture of acids, obtained from cocoa-nut oil.

Bromeis (Ann. Ch. Pharm. xxxv. 277), by saponifying cocoa-nut fat, decomposing the soap with an acid in the usual way, pressing the resulting fatty acid between paper, and recrystallising from alcohol, obtained a nearly inodorous fatty acid, which melted at 35° C., solidified to a porcelain-like mass translucent at the edges, and distilled without decomposition. Saint-Èvre (Ann. Ch. Phys. [3] xx. 95) decomposes the soda-soap of cocoa-nut oil with acetate of lead; exhausts the lead-soap with ether; decomposes the undissolved soap with an acid; and crystallises the fatty acid from alcohol. From a saturated solution in aqueous alcohol, it crystallises, on cooling, in needles; but from a solution in strong alcohol, by evaporation, in amorphous masses. It melts at 34·5° C., and volatilises without decomposition only in a stream of gas.

Bromeis assigned to his cocinic acid the formula $C^{27}H^{27}O^4$, but his analysis, calculated according to the more recently determined atomic weight of carbon ($C = 6$), gives rather $C^{26}H^{26}O^4$, or $C^{13}H^{26}O^2$. Heintz has since announced the separation of an acid of the same composition from spermaceti. Fehling obtained from cocoa-nut oil an acid resembling the acid prepared by Bromeis in appearance and melting point, and corresponding exactly to the formula $C^{13}H^{26}O^2$.

Saint-Èvre, on the other hand, assigned to the cocinic acid which he obtained, the formula $C^{11}H^{22}O^2$, though it agrees very closely with that of Bromeis in the melting point.

Heintz regards the acid $C^{13}H^{26}O^2$ from cocoa-nut oil, and likewise that obtained by himself from spermaceti, as a mixture, especially on account of its melting point, which is lower than that of lauric acid ($C^{12}H^{24}O^2$); whereas if it were really a definite acid, its melting point would be intermediate between those of lauric acid (44° C.) and myristic acid, $C^{14}H^{28}O^2$ (54° C.). He finds, indeed, that a mixture of 14 pts. lauric and 2 pts. myristic acid melts at about 35° C. Saint-Èvre's formula, $C^{11}H^{22}O^2$, is on this account more probable.

Cocinate of barium, crystallised from boiling alcohol, is, according to Bromeis, $C^{26}H^{50}Ba''O^4$. *Cocinate of silver*, $C^{13}H^{25}AgO^2$ (Bromeis), $C^{11}H^{21}AgO^2$ (Saint-Èvre), is obtained by precipitation from alcoholic solutions, in white flocks melting at 55° C., soluble in ether, sparingly soluble in alcohol.

Cocinate of ethyl, $C^{13}H^{25}(C^2H^5)O^2$ or $C^{11}H^{21}(C^2H^5)O^2$, obtained by passing hydrochloric acid gas into a hot alcoholic solution of cocinic acid, washing the product with weak alkali, and drying over chloride of calcium, is a liquid having a faint-yellow colour, a very pungent odour of apples, and a sweet mawkish taste.

COCININ. *Cocinate of glyceryl.*—The name of the neutral fat corresponding to cocinic acid. The separate identity of such a fat, like that of the acid itself, must, for the present be considered doubtful. Brandes (Ann. Ch. Pharm. xv. 115), by expressing the fat from cocoa-nuts, and crystallising it repeatedly from boiling alcohol, obtained a snow-white laminar crystalline fat, of specific gravity 0·92 at 8° C., less soluble in pure than in common ether, soluble in 40 pts. absolute alcohol at 20° C., about 12 pts. at 44° C., sparingly soluble in aqueous alcohol of 0·75 in the cold, more soluble in the same when warm; crystallising on cooling; decomposed by dry distillation.

COCINONE. A product of the decomposition of neutral cocinate of calcium, consisting, according to Delffs (Pogg. Ann. lxxxvi. 587), of $C^{21}H^{42}O$, and therefore the acetone of Saint-Èvre's cocinic acid $C^{11}H^{22}O^2$. When purified by recrystallisation from boiling alcohol, it forms colourless, inodorous, tasteless laminæ, melting at 38° C., and boiling at a temperature beyond the range of the mercurial thermometer.

COCOA-NUT OIL. This oil or fat is obtained by pressure from the fruit of certain cocoa-palms, *Cocos nucifera*, *C. butyracea*, &c., and is imported in large quantities into Europe for the manufacture of soap. It is whitish, of unctuous consistence, with a peculiar disagreeable odour of volatile fatty acids, and a mild taste; it melts at 20° C., dissolves with aid of heat in alcohol and ether, readily in oils, both fixed and volatile, benzene, &c.

Cocoa-nut oil quickly becomes rancid, and is easily saponified. It is a mixture of several glycerides, containing also free fatty acids. By saponification it yields both fixed and volatile fatty acids. The volatile acids, which may be separated by distilling the mixture of free fatty acids with water, consist chiefly of caprylic acid mixed with small quantities of caproic and capric acids. The fixed fatty acids of cocoa-nut oil are partly liquid at ordinary temperatures, partly solid. The former have not been particularly examined; of the latter, several may be isolated by crystallisation from alcohol, viz. lauric acid, $C^{12}H^{24}O^2$, which may be obtained pure, with the melting point 43° C., by fractional precipitation of the soda-soap (Oudemans, J. pr. Chem.

lxxxi. 367); the acid, $C^{11}H^{22}O^2$, which was obtained from the oil by Saint-Évre, and $C^{13}H^{26}O^2$ by Bromeis, (see COCINIC ACID, p. 57); myristic acid, $C^{14}H^{28}O^2$, likewise exists in considerable quantity in cocoa-nut oil. The acid actually obtained had very nearly the composition of myristic acid, and melted at 49° C., the melting point of the pure acid being 53·8° (Fehling, Ann. Ch. Pharm. liii. 399). Görgey (*ibid.* civ. 25) likewise found a fatty acid, $C^{15}H^{30}O^2$, melting at 56° C., which, from the examination of the silver-salt, he regarded as a mixture of myristic and palmitic acids. Fehling also found pure palmitic acid. Stearic acid is probably present in small quantity.

The solid fats of cocoa-nut oil are separated from the more liquid fats by pressure, and used for the manufacture of candles.

The solid fatty acids of cocoa-nut oil are converted, by prolonged treatment with nitric acid, into a mixture of acids of the series $C^nH^{2n-4}O^4$, viz. anchoic, suberic, pimelic, adipic, succinic acid, and an oily mass containing nitrocapric and nitrocaprylic acids.

CODEINE. $C^{18}H^{21}NO^3 + H^2O$ or $C^{36}H^{21}NO^6 + 2HO$.—A non-volatile organic base contained in opium. It was discovered by Robiquet in 1832 (Ann. Ch. Phys. [2] li. 259), and has been further examined by Couerbe (*ibid.* lix. 158), Regnault (*ibid.* lxviii. 136), Gregory (Ann. Ch. Pharm. xxvi. 44), Will (*ibid.* 44), Gerhardt (Rev. Scient. x. 203; *Traité*, iv. 40), and especially by Anderson (Ed. Phil. Trans. xx. [1] 57).

Preparation.—1. The aqueous infusion of opium, evaporated to a syrup, is mixed with solution of chloride of calcium; the mass is diluted with water; the resulting meconate of calcium is separated, washed several times with small quantities of water and pressed; and the liquid thus obtained is evaporated, lumps of marble being thrown into it to neutralise the free acid. Fresh quantities of meconate of calcium then separate, and the decanted liquid, if left at rest, deposits crystals of hydrochlorate of morphine and hydrochlorate of codeine. These crystals are dissolved in water, and the solution, after purification with animal charcoal, is precipitated by ammonia, which separates the greater part of the morphine, leaving the codeine in solution. The filtered liquid is evaporated over the water-bath to expel the excess of ammonia, the morphine salt remaining in solution being at the same time precipitated; the saline solution is concentrated and precipitated by caustic potash; and the precipitate of codeine is washed, dried, and dissolved in ether, whence it is deposited in crystals. (Robiquet.)

2. To obtain the whole of the codeine from the mother-liquor which remains after the morphine has been removed by precipitation with ammonia, as just described, it is necessary to get rid of the sal-ammoniac with which it is mixed. This may be effected by repeatedly concentrating the liquid—the greater part of the hydrochlorate of codeine then separating out, while the sal-ammoniac remains dissolved—and decomposing the remaining sal-ammoniac with caustic potash. By repeating the crystallisation a certain number of times, the hydrochlorate of codeine might be obtained quite free from sal-ammoniac; this, however, would occasion the loss of a considerable quantity of codeine, inasmuch as the two hydrochlorates do not differ greatly in solubility; but if the crystallisation be discontinued at an earlier stage, the greater part of the sal-ammoniac may be removed without loss of codeine. The crystals of hydrochlorate of codeine are then to be dissolved in boiling water, and a strong solution of caustic potash added in excess, which will precipitate the codeine, partly as an oil which gradually solidifies, partly in the crystalline state as the liquid cools. The mother-liquor yields by evaporation a fresh crop of crystals of codeine, and lastly, after reduction to a very small bulk, it becomes filled, on cooling, with long silky needles of morphine, which had been retained in solution by the excess of potash. (Anderson.)

3. Opium is exhausted with cold water, the morphine precipitated by ammonia, the meconic acid by chloride of calcium, and the colouring matter by subacetate of lead. The liquid filtered from the lead-precipitate is freed from lead by sulphuric acid and filtered again; the filtrate is mixed with excess of potash; the mixture left to stand in the air till carbonate of potassium has formed; and the whole agitated with ether, which extracts the codeine. (Winckler, Répert. Pharm. xliv. 459.)

4. Merck (Ann. Ch. Pharm. xi. 279) precipitates the mixture of the hydrochlorates of codeine and morphine with pure soda; treats the precipitate with cold alcohol; saturates the alcoholic solution with sulphuric acid; removes the alcohol by distillation, and adds cold water to the remaining liquid as long as it produces turbidity; then filters, evaporates to a syrup, and agitates the residue with excess of potash and with ether. The codeine dissolves in the ether and is deposited by spontaneous evaporation; it is finally treated with alcohol, to free it from an oily substance which prevents crystallisation.

Purification.—Impure crystals of codeine are purified by dissolving them in hydrochloric acid, boiling with animal charcoal, reprecipitating with caustic potash and finally dissolving the precipitate in ether containing water, in order to free the codeine from the last trace of morphine; the ether used must, however, be free from alcohol, otherwise a syrupy liquid remains, on evaporation, which cannot be made to crystallise. If anhydrous ether be used, the codeine dissolves much more slowly (Handw. d. Chem. ii. [3] 136). 100 pounds of opium yield from 6 to 8 oz. of codeine (Robiquet). The proportion of codeine in opium is from $\frac{1}{20}$ to $\frac{1}{15}$ of that of the morphine. (Anderson.)

Properties.—Codeine crystallises from anhydrous ether in small anhydrous rectangular octahedrons, truncated and modified in various ways. From hydrated ether or alcohol, and from water, it separates in hydrated crystals of the trimetric system. Those deposited from alcohol exhibit the combination $\infty P \,.\, 0P \,.\, \bar{P}\infty \,.\, \breve{P}\infty$; those from water, the combination $\infty P \,.\, \breve{P}\infty \,.\, \frac{1}{2}\breve{P}\infty$. Inclination of $\infty P : \infty P = 87° 40'$; $\bar{P}\infty : 0P = 141° 37'$; $\breve{P}\infty : 0P = 140° 23'$; $\frac{1}{2}\breve{P}\infty : 0P = 157° 25'$. Cleavage parallel to 0P. (Kopp, *Krystallographie*, 266.)

Codeine dissolves in water much more readily than morphine, especially in boiling water. 100 pts. of water at 15° C. dissolve 1·26 pts. codeine, When heated with a quantity of water less than sufficient to dissolve it, it melts to an oily mass, which remains at the bottom of the liquid. It dissolves easily in alcohol and hydrated ether, less easily in anhydrous ether. The alcoholic solution deflects the plane of polarisation of a luminous ray strongly to the left; $[\alpha] = -118·2°$; acids have scarcely any effect on the rotatory power.

Codeine is quite insoluble in potash; it dissolves in ammonia, but not to a greater extent than in pure water.

Anhydrous codeine contains:

	Calculated.		Robiquet.	Couerbe. (*mean.*)	Regnault.	Gregory. (*mean.*)	Will.	Anderson. (*mean.*)
C^{18} . . .	216	72·24	70·36	71·84	73·31	73·05	73·27	72·01
H^{21} . . .	21	7·02	7·58	7·37	7·19	7·21	7·25	7·09
N . . .	14	4·68	5·35	—	4·89	4·89	—	4·50
O^3 . . .	48	16·06	—	—	—	—	—	—
	299	100·00						

The hydrated crystals contain, according to Gerhardt's analysis, 67·82 per cent. C, and 7·46 H, agreeing nearly with the formula $C^{18}H^{21}NO^3 + H^2O$, which requires 68·13 C, 7·25 H, 4·41 N, and 20·21 O.

Codeine is a strong base, quickly restoring the blue colour of reddened litmus, and precipitating the salts of lead, iron, copper, cobalt, nickel, &c.

In its action on the animal economy, codeine resembles morphine in many respects. According to Robiquet, doses of 0·02 to 0·03 grm. produce in 24 hours, especially in excitable persons, a sensation of comfort and repose, and a refreshing sleep, whereas doses of 0·15 to 0·12 grm. produce heavy sleep, with a feeling of intoxication after waking—sometimes also nausea and vomiting; more than 0·2 grm. cannot be taken in 24 hours without danger of serious consequences.

Codeine is said to be sometimes adulterated with sugar-candy; this impurity may be detected by its greater solubility in water, its smaller solubility in alcohol, and its very different action on polarised light. According to Robiquet, a solution of 0·500 grm. pure codeine in 100 cub. cent. alcohol of at least 56 per cent. gives, for the transition tint, a deflection of 11° to the left.

Decompositions.—1. When codeine is dissolved in excess of *sulphuric acid* of medium strength, and the solution is digested in a sand-bath, it acquires a dark colour, and after a while yields a precipitate with carbonate of sodium, which is not the case with codeine-salts in their ordinary state. The precipitate thus formed consists of amorphous codeine, which, after washing with water, solution in alcohol, and precipitation by water, forms a grey powder with more or less green reflection, insoluble in water, easily soluble in alcohol, and precipitated therefrom by ether. It melts at 100° C. to a black resinous mass. It dissolves easily in acids, forming amorphous salts, which dry up by evaporation to brown resins. If the action of the sulphuric acid on the codeine be prolonged, a dark green substance is obtained.

2. *Nitric acid*, according to its degree of concentration, forms with codeine either a basylous nitro-compound (p. 1067), or a yellow resin soluble in alkalis.

3. *Chlorine* and *bromine* form substitution-products (p. 1066).

4. *Iodide of ethyl* heated with codeine forms hydriodate of ethyl-codeine.

5. Codeine gently heated with *hydrate of potassium*, yields several volatile alkalis, viz. ammonia, methylamine and tritylamine, in variable proportion, according to the manner in which the process is conducted. A volatile crystalline base is likewise produced in small quantity, and a brown or black substance remains.

SALTS OF CODEINE.—Codeine is a mono-acid base, dissolving readily in acids, and yielding for the most part crystallisable salts. They are very bitter, are not reddened by nitric acid, and do not impart a blue colour to ferric salts. *Potash* precipitates codeine from their solutions; *ammonia* does not precipitate them immediately, but gives rise, after some time, to the separation of small transparent crystals of codeine. *Infusion of gall-nuts* precipitates codeine-salts immediately.

Chromate of Codeine is easily obtained in beautiful yellow needles.

Hydrochlorate of Codeine, $C^{18}H^{21}NO^3.HCl + 2H^2O$.—A somewhat concentrated solution of codeine in hydrochloric acid, solidifies completely on cooling; a more dilute solution deposits radiate groups of short needles, exhibiting under the microscope the form of prisms with four faces, terminated by dihedral summits. The crystals dissolve in 20 pts. of water at 15·5°C., and in less than their weight of boiling water. They give off ½ of their water at 100° C., the remainder at 121°, part of the acid, however, going off at the same time.

Chloro-aurate of Codeine, obtained by mixing the solutions of the component salts, is a reddish or light-brown precipitate, moderately soluble in hydrochloric acid.

The *Chloromercurate* is obtained in like manner, as a precipitate, soluble in boiling water and in alcohol, and deposited in stellate groups on cooling.

The *Chloroplatinate*, $2(C^{18}H^{21}NO^3.HCl).PtCl^4 + 4H^2O$, separates on adding tetrachloride of platinum to a moderately concentrated solution of hydrochlorate of codeine, as a light-yellow powder, which, if left in the liquid or kept moist on the filter, gradually becomes crystalline, and of an orange-red colour. From very dilute solutions, the double salt separates after some time in silky needles. It dissolves sparingly in cold water, and is decomposed by boiling water. It gives off ¾ of its water at 100° C., the rest at 120°, with incipient decomposition.

Hydriodate of Codeine. $C^{18}H^{21}NO^3.HI + H^2O$.—Long thin needles, soluble in about 60 pts. of cold water, much more soluble in boiling water. They do not give off any water at 100° C.

Hydrocyanate of Codeine is uncrystallisable.—The *hydroferrocyanate*, produced by mixing the alcoholic solutions of codeine and hydroferrocyanic acid, is a white precipitate which crystallises after a while in needles, and dissolves in excess of hydroferrocyanic acid. The *hydroferricyanate* produced by adding aqueous ferricyanide of potassium to hydrochlorate of codeine, is a very unstable crystalline compound.

Nitrate of Codeine, $C^{18}H^{21}NO^3.HNO^3$, is produced by slowly adding nitric acid of specific gravity 1·06 to pulverised codeine, carefully avoiding an excess of the acid, which would produce decomposition. It dissolves easily in boiling water, and separates on cooling in small prismatic crystals. It melts at a moderate heat, and decomposes at a higher temperature, leaving a difficultly combustible charcoal.

Oxalate of Codeine, $2C^{18}H^{21}NO^3.H^2C^2O^4 + 3H^2O$, is deposited on cooling, from a hot saturated solution in short prisms and sometimes in scales. It dissolves in 30 pts. water at 15·5° C., and in about half its weight of boiling water. It gives off its water at 100°, turns brown at about 121°, and decomposes completely at higher temperatures.

Phosphate of Codeine. $C^{18}H^{21}NO^3.H^3PO^4 + \frac{1}{2}H^2O$—A solution of ordinary phosphoric acid saturated with pulverised codeine does not crystallise by concentration, but on addition of strong alcohol immediately deposits scales or short prisms. It is very soluble in water.

Other phosphates of codeine appear also to exist.

Sulphate of Codeine, $2C^{18}H^{21}NO^3.H^2SO^4 + 5H^2O$ (or $C^{36}H^{21}NO^6.HSO^4 + 5HO$) crystallises in radiate groups of long needles, or by spontaneous evaporation, in flattened prisms. It dissolves in 30 pts. of cold water, and is very soluble in hot water. When pure, it is neutral to test-paper; but it is apt to retain a small quantity of acid, which may be separated by repeated crystallisation. The crystals belong to the trimetric system, $\infty P \,.\, \breve{P}\infty \,.\, \infty\breve{P}\infty$. Inclination of $\infty P : \infty P = 151° 12'$; $\infty\breve{P}\infty : \breve{P}\infty = 113° 45'$; $\breve{P}\infty : \breve{P}\infty = 133° 3'$; $\infty\breve{P}\infty : \infty P = 104° 24$. Cleavage parallel to $\infty\breve{P}\infty$.

Sulphocyanate of Codeine. $C^{18}H^{21}NO^3.HCyS + \frac{1}{2}H^2O$.—Radiate needles melting at 100° C., giving off 2·45 per cent. water (= ½ at.) at 100° C.

Tartrate of Codeine is uncrystallisable.

Substitution-products of Codeine.

BROMOCODEINE. $2C^{18}H^{20}BrNO^3 + 3H^2O$ (Anderson *loc. cit.*)—Prepared by adding bromine-water in small successive portions to pulverised codeine. The codeine dissolves, and the solution loses the colour of bromine but acquires a characteristic reddish tint. On adding ammonia, the whole of the bromocodeine is precipitated as a silver-white powder, containing a small quantity of unaltered codeine. It may be obtained pure by repeated washing with cold water, solution in hydrochloric acid, precipitation with ammonia and crystallisation from alcohol.

Bromocodeine is nearly insoluble in cold water, rather more soluble in hot water, whence it separates on cooling in small prisms with dihedral summits. It is nearly insoluble also in ether, but dissolves easily in alcohol, especially at the boiling heat. Better crystals are obtained from alcohol diluted with an equal volume of water. The crystals are always very small, but of dazzling whiteness. They give off their water (6·66 per cent.) at 100° C. The anhydrous base gives by analysis 57·44 per cent. C, 5·44 H, and 21·5 Br, the formula $C^{18}H^{20}BrNO^3$, requiring 57·14 C, 5·29 H, 21·16 Br, 3·70 N, and 12·71 O.

Bromocodeine melts when heated, forming a colourless liquid, which decomposes at a somewhat higher temperature. It dissolves in cold sulphuric acid, the solution becoming dark coloured when heated. It is attacked by nitric acid, but much less quickly than codeine.

Hydrobromate of Bromocodeine, $C^{18}H^{20}BrNO^3.HBr + H^2O$, forms small prisms, sparingly soluble in cold water, very soluble in boiling water. It gives off its water at 100° C. The *hydrochlorate* forms radiate needles, resembling hydrochlorate of codeine. The *chloroplatinate*, $2(C^{18}H^{20}BrNO^3.HCl).PtCl^4$ (at 100° C.), is precipitated as a pale-yellow powder, insoluble in water and in alcohol (platinum, by analysis, 16·98 per cent.; by calculation 16·89).

Tribromocodeine, $C^{18}H^{18}Br^3NO^3$ (Anderson, *loc. cit.*)—When bromocodeine is subjected to the continued action of bromine-water in excess, a light-yellow precipitate of hydrobromate of tribromocodeine is formed, which redissolves at first, but becomes permanent on further addition of bromine. On leaving the liquid to itself for 24 hours and then adding more bromine, a fresh precipitate is formed, and this treatment must be repeated day after day as long as any further precipitate is thrown down by adding bromine. The yellow precipitate is then to be washed with cold water, and dissolved in hydrochloric acid; and the base precipitated by ammonia, purified by solution in alcohol, and precipitated by water.

Tribromocodeine thus prepared is an amorphous bulky powder, grey when dry, insoluble in water and ether, easily soluble in alcohol. It dissolves somewhat sparingly in cold, more easily in hot hydrochloric acid, a small portion however remaining undissolved, apparently from partial decomposition. It turns brown when heated on platinum-foil, and decomposes completely at its melting point, leaving a very slowly combustible charcoal.

Tribromocodeine is but a weak base; its salts are all soluble in water and amorphous. The *hydrobromate*, $2C^{18}H^{18}Br^3NO^3.3HBr$, obtained as above, is a light-yellow perfectly amorphous powder, sparingly soluble in cold, more soluble in hot water. The *chloroplatinate*, $2(C^{18}H^{18}Br^3NO^3.HCl).PtCl^4$, is obtained by precipitation, as a brown-yellow powder, insoluble in water and in alcohol (platinum, by analysis, 13·07 per cent.; by calculation, 13·29).

CHLOROCODEINE, $2C^{18}H^{20}ClNO^3 + 3H^2O$. (Anderson, *loc. cit.*)—Dry codeine treated with chlorine gas, yields a number of complex products, which have not been examined. By passing chlorine into the aqueous solution of codeine, a nearly black liquid is produced, from which ammonia throws down an amorphous resinous base. A more definite reaction is obtained by treating codeine with chlorate of potassium and hydrochloric acid. Finely pulverised chlorate of potassium is gradually added to a solution of codeine in hydrochloric acid at 65°—70° C. till the liquid yields a precipitate on addition of ammonia. Excess of ammonia is then added, which throws down chlorocodeine as a silver-white or generally somewhat yellowish crystalline powder, while a reddish liquid remains, containing products of a further decomposition. In this process, the same precautions must be observed as in the preparation of nitrocodeine (p. 1068). The chlorocodeine is freed from a small quantity of undecomposed codeine by solution in hydrochloric acid, boiling with animal charcoal, precipitation with ammonia, and crystallisation from a hot alcoholic solution.

Chlorocodeine resembles bromocodeine in most of its properties. It dissolves sparingly in boiling water, and crystallises on cooling in small prisms, which appear to be isomorphous with the crystals of bromocodeine. It is very soluble in strong alcohol, especially if hot; sparingly soluble in ether. The crystals give off their water (7·48 per cent.) at 100° C. The dried base gives by analysis 65·31 per cent. C, 6·11 H, and 10·32 Cl, the formula $C^{18}H^{20}ClNO^3$ requiring 64·76 C, 5·99 H, 10·64 Cl, 4·19 N, and 14·42 O.

Chlorocodeine dissolves without alteration in strong sulphuric acid; but the solution is carbonised by heat. Nitric acid also dissolves it, and the solution decomposes on boiling, though, much less easily than that of codeine, giving off nitrous gases and a very pungent vapour.

The *salts of chlorocodeine* resemble those of bromocodeine. The *chloroplatinate* is a pale yellow precipitate, which after drying at 200° C. yields 18·29 per cent.

Pt.; agreeing with the formula $2(C^{18}H^{20}ClNO^3.HCl).PtCl^4$. The *sulphate*, $2C^{18}H^{20}ClNO^3, H^2SO^4 + 8H^2O$, is deposited from a hot solution in radiate groups of short prisms, very soluble in boiling water and in alcohol.

Cyanocodeine, $C^{18}H^{21}NO^3.Cy^2$ (**Anderson**, *loc. cit.*)—This compound, which is not a substitution-product like the preceding, but rather a **cyanide of codeine**, is produced when cyanogen gas is slowly passed into a concentrated alcoholic solution. The gas is abundantly absorbed, the liquid first turning yellow, then brown; the odour of cyanogen gradually disappears, and is replaced by that of hydrocyanic acid; and crystals are deposited, continually increasing in quantity, as the passage of the gas is continued. The mother-liquor separated from the crystals yields an additional quantity if again treated with cyanogen gas. The crystals are washed with a small quantity of alcohol, and dissolved in a hot mixture of ether and alcohol, into which solution cyanogen is again passed to transform any codeine that may have remained unacted on. Cyanocodeine then separates in thin, shining, colourless or faintly yellow, six-sided laminæ. It dissolves easily in boiling absolute alcohol, or in a mixture of alcohol and ether, sparingly in water, more easily on addition of alcohol; this solution however does not deposit anything when left at rest, and decomposes by evaporation, leaving a residue of codeine.

Cyanocodeine yields by analysis 68·13 per cent. C, 6·05 H, and 11·66 N, calculation requiring 68·37 per cent. C, 5·97 H, 11·68 N, and 13·97 O.

[It is perhaps a hydrocyanate of cyanocodeine, $C^{18}H^{20}CyNO^3.HCy$.]

With *hydrochloric acid*, it forms a crystallisable salt, which however quickly decomposes, giving off ammonia on addition of potash; the hydrochloric acid solution, if left to stand for twenty-four hours, gives off hydrocyanic acid. With *oxalic* and *sulphuric* acids, cyanocodeine forms sparingly soluble salts which likewise decompose quickly, giving off ammonia and hydrocyanic acid. (**Anderson.**)

Ethylcodeine, $C^{20}H^{25}NO^3 = C^{18}H^{20}(C^2H^5)NO^3$. (**H. How**, Chem. Soc. Qu. J. vi. 125.)—The hydriodate of this base is obtained by enclosing in a sealed tube pulverised codeine with a small quantity of iodide of ethyl and sufficient absolute alcohol to dissolve the codeine, and heating the mixture in the water-bath for two hours. On cooling, a crystalline mass is obtained, very soluble in cold water, whence it is deposited, after concentration, in tufts of fine needles. Dried at 100° C., it contains 52·59 per cent. C, 5·87 H, and 27·91 I, agreeing nearly with the formula $C^{18}H^{25}NO^3.HI$, which requires 52·73 C, 5·76 H, and 27·92 I.

The solution is not precipitated either by potash or by ammonia. Treated with oxide of silver, it yields a strongly alkaline liquid which absorbs carbonic acid during evaporation. The residue is again attacked by iodide of ethyl, but the reaction appears to be very complicated.

Iodocodeine, $C^{18}H^{21}NO^3.I^3$. (**Anderson**, *loc. cit.*)—This compound—which should rather be called **iodide of codeine**, for it is not a substitution-product—is prepared by dissolving equal weights of iodine and codeine in the smallest possible quantities of alcohol, mixing the solutions, and leaving the mixture at rest; iodocodeine is then deposited, after a longer or shorter time, according to the concentration of the solutions, in triangular plates belonging to the triclinic system; they have a fine ruby colour by transmitted light, deep violet by reflected light, and if well illuminated, exhibit a beautiful adamantine, nearly metallic lustre. They are insoluble in water and in ether, but dissolve in alcohol with red-brown colour. After drying in vacuo, they contain, according to the mean of Anderson's analyses, 32·07 per cent. C, 3·39 H, and 55·32 I, the formula requiring 31·75 C, 3·08 H, and 56 I.

Iodocodeine gives off iodine at 100° C. It is dissolved by hot sulphuric acid, and slowly attacked by hot nitric acid. Boiling potash dissolves out the iodine and leaves codeine. With sulphuretted hydrogen, it yields hydriodate of codeine, with deposition of sulphur. With nitrate of silver, it forms an immediate precipitate, which, however, contains only about $\frac{1}{3}$ of the iodine in the compound. (**Anderson**, *loc. cit.*)

Nitrocodeine. $C^{18}H^{20}N^2O^5 = C^{18}H^{20}(NO^2)NO^3$. (**Anderson**, *loc. cit.*)—To prepare this base, dilute nitric acid, of specific gravity 1·060, is heated in a flask to a temperature short of ebullition, finely pulverised codeine is added, and the mixture is kept at a gentle heat for a few minutes, till a sample of it gives a precipitate with ammonia, and the quantity of this precipitate no longer increases after several trials. The whole of the solution is then saturated with ammonia and briskly agitated, whereby a thick precipitate of nitrocodeine is formed. The action of the nitric acid is very rapid, the transformation being complete in a few minutes, so that close watching is necessary to seize the exact point at which the liquid should be saturated with ammonia. Evolution of red vapours is a sign that the action has gone too far, and that a portion of the codeine has been converted into a peculiar red substance, not yet examined. In this case, it is best to interrupt the process before the whole of the codeine is decomposed. Strong nitric acid acts on codeine with violence, producing a yellow resin.

Nitrocodeine precipitated by ammonia, as above, forms very small silvery laminæ, slightly tinged with yellow. It is purified from colouring matter and a little unaltered codeine, by solution in hydrochloric acid, boiling with animal charcoal, reprecipitation by ammonia, and recrystallisation from dilute alcohol or ether-alcohol. From alcohol it crystallises in thin silky laminæ of a pale tawny colour, forming, when dry, an interlaced silky mass. From ether-alcohol it separates, by evaporation, in small yellowish crystals, exhibiting under the microscope the form of quadrilateral prisms with dihedral summits. It is sparingly soluble in boiling water, and separates in small crystals on cooling. It dissolves readily in boiling alcohol, sparingly in ether. It gives by analysis 62·49—63·10 C, and 5·91—6·04 H, the formula requiring 62·79 C, and 5·81 H.

Nitrocodeine when cautiously heated melts to a yellow liquid, which solidifies to a highly crystalline mass. At a higher temperature, it decomposes quickly, without flame, leaving a bulky charcoal. When the alcoholic solution of nitrocodeine is treated with sulphide of ammonium at the heat of the water-bath, it acquires a dark colour and deposits sulphur. When the action is complete, the filtered liquid yields with ammonia a brown amorphous precipitate, which, after solution in hydrochloric acid, boiling with animal charcoal, and reprecipitation, forms a pale yellow basic substance (*azocodeine*), which has not been further examined.

Nitrocodeine dissolves in acids, forming salts which are neutral to test-papers, and from which the base is precipitated as a crystalline powder by potash or ammonia.

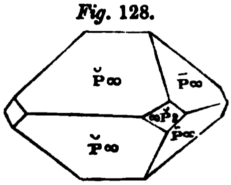
The *hydrochlorate* is obtained by evaporation in the form of an uncrystallisable resinous mass. The *chloroplatinate*, $2(C^{18}H^{20}(NO^2)NO^3.HCl).PtCl^4 + 4aq.$, is a yellow precipitate, insoluble in water and in alcohol. It gives off its water at 100° C., and then yields by analysis 17·88 per cent. Pt (calc. 17·93).

The *oxalate* crystallises in short yellow prisms, very soluble in water. The *sulphate*, $2C^{18}H^{20}(NO^2)NO^3.H^2SO^4 + 2aq.$ (at 100° C.), is obtained in radiate groups of short pointed needles, neutral to test-paper, and very soluble in boiling water.

COD-LIVER OIL. See OILS, ANIMAL.

CŒLESTIN. $Sr''SO^4$ or $SrO.SO^3$.—Native sulphate of strontium. This mineral is so named from its occasional delicate blue colour; though it is frequently found of other shades, as white, greyish and yellowish-white, and red. It occurs massive, and crystallised, sometimes also in fibrous and stellated forms. It belongs to the trimetric system, being isomorphous with sulphate of barium and sulphate of calcium. The primary form is a rhombic prism of 104° 20′ and 75° 40′. An ordinary combination is $\bar{P}\infty$. $P\infty$. $\infty\breve{P}2$ (*fig.* 128). Cleavage very distinct parallel to $\breve{P}\infty$; less distinct parallel to $\bar{P}\infty$. It has a vitreous lustre, and is transparent, translucent, or opaque. It is very brittle. Specific gravity 3·953 (Breithaupt). Hardness 3—3·5. Before the blowpipe it fuses to a white, opaque, friable enamel. Cœlestin occurs abundantly in the massive form at Montmartre, and near Bristol. The crystallised variety is found in the red sandstone at Inverness, and in many other localities. Splendid groups of crystals occur at Girgenti in Sicily, mixed with sulphur and gypsum. Fine specimens are also met with at Bex in Switzerland, Conil in Spain, Retzbanya in Hungary, in compact limestone near Lake Erie, and many other localities. Crystals of cœlestin are often found in which the strontium is partially replaced by barium or calcium, the substitution being attended with a certain alteration in the magnitude of the angles of the crystal. The blue colouring of certain specimens of cœlestin appears to be due to the presence of small quantities of ferrosoferric phosphate. (Jahresber. f. Chem. 1847, 1219; 1849, 776; 1850, 757; 1853, 842; 1855, 970; 1856, 874; 1857, 692.—Dana, ii. 368.)

Fig. 128.



CŒLOCLINE POLYCARPA. The tree which yields the Abeocouta bark of West Africa, where it is used for colouring skins, mats, &c.; also as a local application for ulcers. According to Stenhouse, the bark contains berberine.

CŒRULIC ACID. According to Vlaanderen and Mulder (Jahresb. f. Chem. 1858, p. 262), caffeic or caffetannic acid (i. 709), which they regard as $C^{14}H^{16}O^7$, yields by oxidation, *caffeanic* acid, $C^{14}H^{16}O^8$, and from this, by the action of air and ammonia, are produced *α-cærulic* acid, $C^{14}H^{16}O^9$, and *β-cærulic* acid, $C^{14}H^{14}O^8$, both of which form blue salts, and consequently resemble viridic acid (*q. v.*)

CŒRULIN. A name sometimes applied to the body $C^8H^{15}NO$, supposed to exist in sulphindigotic acid, $C^8H^{15}NO.SO^3$.

COFFEE. *Café. Kaffee.*—Coffee beans are the seed of *Caffea arabica*, a tree of the rubiaceous order, indigenous in southern Abyssinia. It is said to have been transplanted into Arabia at the beginning of the fifteenth century, and the cultivation has since been extended to the West Indies, Brazil, Java, Ceylon, and other warm countries. The seeds are separated from the soft pods by bruising with a heavy roller, then washed and dried, and lastly freed from their parchment-like coating by passing them under a wooden edge-wheel, and subsequently winnowing. In this state they are sent to Europe.

The most highly esteemed variety is the Mocha coffee, which is grown in the province of Yemen in Arabia: it has a more agreeable taste and smell than any other kind, and is distinguished by its yellow colour and the comparative smallness and roundness of the bean. Next to it in European reputation, are the Martinique and Bourbon coffees; the former is larger than the Arabian and more oblong; it is rounded at the ends, of greenish colour, and almost always retains a silver-grey pellicle which comes off in roasting. The Bourbon coffee approaches nearest to the Mocha, from which it originally sprung. The Saint Domingo coffee, which has its two extremities pointed, is much less esteemed than the preceding.

The chemical properties and composition of coffee beans have been made the subject of numerous investigations. Schroeder in 1808 (Gehler's J. Chem. Phys. vi. 564), showed that they contain fat, resin, mucus, extractive matter, &c., and that the aqueous extract is coloured green by ferroso-ferric salts, and yields a green precipitate with copper-salts on addition of an alkali.—Runge in 1820 (*Materalien zur Physiologie*, Lief i. p. 146) discovered caffeine: and Pfaff (*Syst. d. Materia Medica*, iii. 3) found in the beans, in addition to this substance, two acids, viz. caffeic and caffetannic acids, which, however, were afterwards shown by Rochleder to be identical. The examination of coffee-beans was further carried out by Robiquet and Boutron (J. Pharm. xxiii. 101), who found, in addition to fat, extractive matter, and caffeine, a white crystallisable substance, and an acid precipitable by neutral acetate of lead;—by Rochleder (Ann. Ch. Pharm. l. 224; lix. 300; lxiii. 193; lxvi. 35), who found legumin, and a very small quantity of citric acid (a few grains in a pound of coffee);—afterwards by Payen (Ann. Ch. Phys. [3] xxvi. 108), von Bibra (*Narkotische Genussmittel*, u. s. w. Nürnberg, 1855), and lastly by Graham, Stenhouse, and Campbell (Chem. Soc. Qu. J. ix. 33). According to Payen, the caffeine exists partly in the free state, partly as caffetannate of caffeine and potassium (a view considered as doubtful by Graham, Stenhouse, and Campbell). Payen also found sugar in the unroasted beans. According to Graham, Stenhouse, and Campbell, the unroasted beans contain, partly cane-sugar, partly another kind of sugar, probably in combination as a glucoside, the total amount of sugar in various kinds of coffee varying from 6·0 to 7·5 per cent. The caffeine amounts to 1·0 per cent. according to Payen; from 0·5 to 1·0 according to Graham, Stenhouse, and Campbell. The amount of fat appears to vary considerably. According to Rochleder, the beans contain olein and palmitin, perhaps also laurostearin. Robiquet and Boutron found in 8 pts. of Martinique coffee, 1 pt. of fat. Payen found that Mocha coffee contains about 13 per cent. of fat, which is rather greater than the proportion in Martinique coffee. The fat of Mocha coffee also retains the odoriferous principle more tenaciously than that of other varieties; it is yellowish, very fluid, and separates only into two portions of different melting points, whereas that of Martinique coffee has a more brownish colour, is less fluid, and may be separated into at least four distinct fats, melting at about 5°, 20°, 50°, and 90° C. respectively, the last being a kind of vegetable wax. According to Stenhouse, coffee beans contain about 12 per cent. of fat. According to Vogel, benzene extracts from them 18 per cent. of soluble matter.

The following is the average composition of raw coffee beans, as determined by Payen and von Bibra:—

	Payen.		v. Bibra.
Cellulose	34	Woody fibre	36 to 59
Water	12	Water	5 to 9
Fat	10 to 13	Fats	8 to 5
Glucose, dextrin, and organic acid	15·5	Sugar	6 to 7
Legumin and Casein	10	Vegetable casein	undetermined
Other nitrogenous substances	3		
Caffeine (free)	0·8	Caffeine	0·2 to 0·8
Caffetannate of caffeine and potassium	3·5 to 5·0	Essential oil	not weighable
Viscid essential oil (insoluble in water)	0·001	Substances precipitable by neutral acetate of lead	7 to 8
Aromatic oils, some lighter, [illegible] water	0·002	Precipitable by basic acetate of lead	5 to 6
[illegible]	6·7	Ash	6 to 7

Levi (Ann. Ch. Pharm. l. 421) found 3·2 per cent. ash.—**T. J. Herapath** (Chem. Gaz. 1848, p. 159) found 6·7 per cent. in the dry beans. Vogel found 3·5 per cent. ash, of which 0·80 was soluble in water.

Composition of the Ash of Coffee-beans in 100 parts.

	Levi.	Herapath.	Graham, Stenhouse, and Campbell.						
			Ceylon cult.	Ceylon wild.	Java.	Costa Rica.	Jamaica.	Mocha.	Neilgherry.
Potash . . .	50·9	16·5	55·1	52·7	54·0	53·2	53·7	51·6	55·8
Soda	14·8	7·1							
Lime	4·8	27·7	4·1	4·6	4·1	4·6	6·1	5·9	6·7
Magnesia . .	10·9	5·9	8·2	8·5	8·2	8·7	8·4	8·9	8·5
Ferric oxide .	0·6		0·45	0·98	0·73	0·63	0·44	0·44	0·61
Sulphuric acid anhydrous .	trace.	1·3	3·6	4·5	3·5	3·8	3·1	5·2	3·1
Carbonic acid anhydrous .	—	—	17·5	16·9	18·1	16·9	16·4	17·0	14·9
Phosphoric acid anhydrous	13·6	40·7	10·2	11·6	11·0	10·8	11·1	10·1	10·8
Chlorine . . .	1·2	0·4	1·1	0·5	0·8	1·0	0·7	0·6	0·6
Silica	3·6	0·4							

From the analysis of the six varieties by Graham, Stenhouse, and Campbell, which exhibit a remarkably close agreement, it appears that coffee-ash is especially distinguished by the absence of soda and silica. The soda found by Levi is doubtful, and Herapath's results, which differ enormously from all the rest, may be rejected as untrustworthy.

Roasting Coffee.—Coffee-beans, when heated or roasted, assume a light brown, chestnut-brown, or even black colour, according to the degree of heat applied. The air-dried beans diminish in weight during roasting by 15 or 25 per cent., but increase considerably in volume, the increase amounting, according to v. Bibra, to from 50 to 58 per cent., if they have been previously washed, or if they are strongly heated. According to Payen, 100 grms. of raw coffee-beans yield 50 grms. of roasted beans, and 100 vols. of the beans increase by roasting to 130 vols. To roast the beans with perfect regularity, it is best to steep them in water for ten or twelve minutes, then to dry them lightly, after draining, and roast them immediately. The steeping removes impurities, and perhaps also serves to impart to the beans a uniform amount of water, so that they get more regularly heated.

The vessels used for roasting coffee are generally of iron: recently silver and glass vessels have also been used for the purpose. The chief point to be attended to in their construction and use, is to ensure that the heat be gradual and not too strong. If the beans are heated above the temperature required to brown them, they swell up strongly, turn black, and ultimately become carbonised. (See *Ure's Dictionary of Arts, Manufactures, and Mines*, i. 794.)

By heating coffee-beans in a retort with proper condensing apparatus, the following volatile products are successively obtained (v. Bibra):

1. A volatile oil, pre-existing in the raw beans, and little, or not at all altered by heat.
2. Volatile oil having the odour of roasted coffee.
3. Empyreumatic oil.
4. A fatty body.
5. Acetic acid.
6. A small quantity of caffeine, together with an aromatic body, probably assamar (i. 428).
7. Humoïd substances, and one or more compounds which easily reduce gold and silver-salts.

The statement of Rochleder that pyrocatechin is formed in the distillation (from the caffetannic acid), is not confirmed by the observations of Graham, Stenhouse, and Campbell.

The composition of roasted coffee has been investigated by Payen, by v. Bibra, and by Graham, Stenhouse, and Campbell. Payen exhausted 100 grms. of ground coffee with a litre of boiling water; heated the filtrate in a distillatory apparatus for two hours, by which time it had quite lost its odour; and collected the distillate in four connected receivers, the first of which gradually became heated to about 90° C., while the second was kept between 25° and 30°, and the third and fourth were cooled to 0°, or a little below, the vapours which escaped from the fourth being passed through strong sulphuric acid, or through a tube filled with red-hot oxide of copper.

In the first receiver, a yellowish water collected, and a few drops of oil, amounting to about $\frac{1}{10}$ of the infusion, floated on the surface, quite destitute of fragrance. The liquid condensed in the second receiver amounted to about $\frac{1}{100}$ of the volume of the infusion: a few drops of an odourless fixed oil floated on the top of the watery liquid, which possessed the fragrant odour of coffee in so high a degree that a few drops of it sufficed to impart the odour to a cup of milk. The water of this second receiver contained the principal part of the coffee-aroma, concentrated about 100 times. On agitating the water with about $\frac{1}{8}$ of its volume of ether, repeating this treatment several times, and then evaporating the ether, there remained a yellowish oil (about 0·1 grm. from 10 grms.), the very strong odour of which resembled that of the aroma common to the several varieties of coffee. Another oil, somewhat more volatile, and of more delicate aromatic odour, remained, together with a little ether, in the water: this oil appears to be contained especially in the finer kinds of coffee, as that of Mocha.

To obtain the whole of the oils from the infusion of coffee, lumps of chloride of calcium are introduced into the first two receivers during the distillation; the third receiver is connected with a chloride-of-calcium-tube and cooled to + 20° C. A solution of chloride of calcium is then obtained, containing the whole of the volatile coffee-oil, which may be extracted from it by agitation with ether. Payen obtained from 10,000 pts. of coffee only 2 pts. of this oil, but possessing so strong an odour that a single drop sufficed to fill a whole room with the characteristic odour of coffee.

If the third receiver be cooled to − 2° or − 3° C. during the distillation, a few drops of liquid collect in it having the odour of coffee, but likewise the less agreeable odour of empyreumatic hydrocarbons, which are present in greater quantity in proportion as the coffee has been more strongly roasted. The odour of these bodies is perceptible also in the fourth receiver and in the vapours which escape therefrom, these vapours likewise imparting a brown colour to oil of vitriol.

According to Zenneck, the aroma of coffee is obtained in larger quantity by adding sulphuric acid to the liquid in the retort.

Von Bibra, by exhausting roasted coffee-beans with ether, obtained from Mocha coffee 8·8 to 9·3 per cent. fatty matter; from Java coffee 8·9 to 9·2 per cent. He supposes that this fat is for the most part produced during the roasting, inasmuch as the raw beans yielded only from 4 to 5 per cent. of fat; and, if the beans thus exhausted were subsequently roasted, they yielded an additional 4 to 6 per cent. fat on being again treated with ether. It is possible, however, that the fat in the raw bean is enclosed in cells, and does not become accessible to the ether till the envelopes are burst by the heat.

The fat extracted by ether has the consistence of cacao-butter (i. 699), and exhales the peculiar aroma of coffee, which appears to be produced from the volatile oil of the raw beans by roasting; by boiling the fat with water this aroma is driven off. The fat is a mixture of several substances, some of which are likewise soluble in alcohol. It appears to contain olein and palmitin, together with a resin and a hydrocarbon; perhaps also other bodies. The ethereal extract likewise contains the whole of the caffeine, and a body which colours iron-salts greenish, precipitates lead-salts, and reduces gold and silver-salts.

When ground coffee which has been exhausted with ether, is twice heated with boiling water, after drying, a dark brown, strongly acid liquid is obtained, having a very bitter taste, but without the peculiar agreeable flavour of coffee. The aqueous extract likewise contains sugar, humoïd substances, assamar, and tannic acid, nearly identical with caffetannic acid; also a substance which reduces gold- and silver-salts, a small quantity of empyreumatic oil, salts, and indifferent substances insoluble in alcohol. The brown bitter products in roasted coffee appear to be produced chiefly from the sugar, inasmuch as that substance diminishes greatly in quantity, or disappears altogether, in the roasting process. Graham, Stenhouse and Campbell found that, whilst the raw beans contained 5·7 to 7·8 per cent. sugar, the roasted beans never contained more than 1·1 per cent., and in many instances none at all.

The residue, after extraction with ether and water, yielded by boiling with water containing carbonate of sodium, a solution coloured deep brown by humoïd substances.

Decoction of coffee does not contain albumin or legumin.

Graham, Stenhouse, and Campbell found in roasted coffee, a brown volatile oil (the *caffeone* of Boutron and Frémy). heavier than water, easily soluble in ether, sparingly in boiling water, but communicating to the water a strong aromatic odour. They also found from 2·5 to 3·0 per cent. nitrogen and sometimes a little sugar.

Von Bibra finds that when ground coffee is treated with boiling water in a French coffee-machine,—in which the boiling water is forced by the pressure of its own vapour from the lower vessel into the upper, which contains the coffee,—from 10 to 12 pts. out of 100 of the coffee pass into the solution: by complete exhaustion, a larger proportion would of course be dissolved. The proportion of soluble matter is increased, up to a certain point, by strong roasting. According to Cadet, coffee roasted to a red-brown colour yields 12·3 per cent.; chestnut-brown coffee 18·5 per cent.; and dark brown 23·7 per cent. of soluble constituents. Payen obtained 37 per cent., and the residue, after thorough exhaustion with water, yielded only 1·2 per cent. ash, ⅙ of which consisted of soluble salts. Lehmann found in roasted Java coffee, 21·5 per cent. soluble matter. Vogel found 39 per cent. (in the raw beans only 25 per cent.). Soft water dissolves out more than hard water; water containing carbonate of soda most of all.

The aqueous extract of coffee yields 16·6 per cent. ash, containing 51·5 per cent. K^2O, 3·6 CaO, 8·6 MgO, 0·2 Fe^2O^3, 10·0 P^2O^5, 40·0 SO^3, 20·5 CO^2, 2·0 KCl, 0·7 SiO^2, with 0·5 sand and charcoal.

Physiological action.—Coffee acts physiologically in two ways: first, by stimulating the action of the nervous and vascular systems, thereby producing a feeling of cheerfulness and mental activity; secondly, by retarding the transformation of tissue, and thus, to a certain extent, supplying the place of other nutriment. Experience has in fact shown that labourers who habitually take coffee as a beverage, require less nitrogenous food to keep up their strength than those who do not take coffee. The stimulating and invigorating action of coffee appears to depend both upon the empyreumatic oil and the caffeine; the retardation of tissue-transformation, chiefly on the empyreumatic oil, the caffeine acting in this manner only when it is present in considerable quantity. The unpleasant symptoms which sometimes attend an excessive use of coffee, such as headache, trembling, and a peculiar delirious sensation, are mainly due to the caffeine (J. Lehmann, Ann. Ch. Pharm. lxxxvii. 207). The assamar and tannic acid in roasted coffee doubtless also contribute in some way to its physiological action.

Tea resembles coffee in containing theine (identical with caffeine) and tannic acid; and, accordingly, its action resembles that of coffee to a certain extent; it differs from coffee, however in not containing the peculiar empyreumatic oils just mentioned, and in being richer in theine and tannin.

Adulteration of Coffee. (Graham, Stenhouse, and Campbell, *loc. cit.*)—Various substances, more or less resembling coffee, are used, either as substitutes for, or additions to it. A great variety of seeds were tried in France during the continuance of the continental blockade, including—in addition to maize, barley, oats, and the other cereals—the seeds of the yellow flag (*Iris pseudo-acorus*), the grey or chick pea (*Cicer arietinum*), the milk vetch or Andalusian astragalus (*Astragalus boeticus*), the *Hibiscus esculentus*, the holly, Spanish broom, acorns, chestnuts, the small lupine (*Lupinus augustifolia*), peas, haricots, horse-beans, sunflower, pips of the gooseberry and grape eglantine (*Rosa villosa*), and the capsules of box (*Buxus sempervirens*). Of these the yellow flag, a common marsh-plant in England, appears to offer the greatest similarity to coffee; but it is doubtful whether the resemblance extends beyond the aroma of the seed when roasted. Indeed no seed appears to be known which, when roasted and pulverised, forms a true and efficient substitute for coffee, either in the physiological properties or in the chemical composition of the soluble extract. The poorer sorts of coffee-beans are sometimes tinted by dusting them with coloured powders, such as Prussian blue, powder of lime-tree charcoal, green earth, &c., mixed with a little graphite, to give them the silvery appearance of the finer sorts.

The use of certain roots roasted and pulverised, to mix with ground coffee, is, however, much more common. The roots most used for this purpose are those of chicory (*Cichòrium intybus*), carrot, beet, rush-nut (*Cyperus esculentus*), earth-nut (*Arachis hypogæa*), scratch-weed (*Galium aparine*), fern (*Polypodium filix mas*), and butcher's-broom (*Ruscus aculeatus*).

These roots are prepared by cutting them into thin slices, drying them on a stove, and then passing them through a coffee-roaster, generally with addition of about 2 per cent. of butter, and sometimes of a red powder, to give them the colour of coffee. In this country and in France, the root most used as an addition to coffee is chicory, the annual consumption of which in France amounts to 6,000,000 kilogrammes. In Germany, beet and carrot are extensively used for the same purpose. Not one of these roots contains either caffeine or the peculiar aromatic oils of roasted coffee, and hence they can never serve as efficient substitutes for coffee; but they are valued as an addition to it, because they contain a large quantity of sugar—chicory as much as 30 per cent.—and consequently, when roasted, acquire the peculiar bitter taste and somewhat of the aroma of caramel or burnt sugar, which is well known to be one of the strongest and most general of our gustatory preferences, being that which gives the peculiar flavour to the several varieties of brown beer or porter (i. 529).

The examination of a sample of ground coffee for the detection and estimation of these admixtures, is a matter of some difficulty. As none of the roots contain caffeine, the quantitative determination of that base in the sample may give an approximation to its degree of purity. For this purpose, the coffee may be exhausted by repeated boiling with hot water; the solution concentrated a little by evaporation; the caffetannic acid, and certain other substances, precipitated first by neutral and then by basic acetate of lead; the excess of lead removed from the filtrate by sulphuretted hydrogen; the liquid then evaporated to dryness; the dry matter exhausted with spirit of specific gravity 0·840; and the alcoholic solution concentrated to a nearly syrupy state, and left to stand for ten days. The crystals of caffeine, which then separate, are collected on a small filter, compressed powerfully to remove the mother-liquor, then redissolved in a small quantity of water, and the solution is evaporated and crystallised anew. It yields almost pure caffeine, the quantity of which in the sample is thus determined. Samples of pure coffee of several varieties yielded, by this treatment, from 0·80 to 1·01 per cent. caffeine; if then the amount obtained from a given sample be less than 0·80, the admixture of some other substance may be inferred. (Graham, Stenhouse, and Campbell.)

If it be desired merely to determine whether a given sample of ground vegetable substance contains coffee or not, the search for caffeine may be made by a simpler process, namely, by evaporating the aqueous infusion to dryness after addition of lime, treating the dry mass with ether, leaving the solution to crystallise by evaporation, and testing the crystals with nitric acid and ammonia, whereby, if caffeine be present, the purple colour of murexid is produced (i. 708).

The formation of quinone by the oxidation of caffetannic acid (i. 709), may also be used as a means of recognising the presence of coffee in a mixture. For this purpose the infusion of the powder is evaporated to syrup, and 1 pt. of the residue is distilled with 4 pts. peroxide of manganese, and 1 pt. oil of vitriol diluted with 1 vol. water; quinone is then given off, part subliming in crystals, while the rest passes over with the watery distillate. (Graham, Stenhouse, and Campbell.)

The adulterations of coffee are most easily detected by their physical characters, by the proportion of sugar contained in the sample, and by the composition of the ash.

1. *Action of Water.*—When hot water is applied to the powder of chicory and other roots, it softens immediately, from the facility with which the water is imbibed; whereas the grains of coffee remain hard and gritty. Roasted grain, such as wheat and barley, gives with hot water a thick mucilaginous infusion, while the infusion of coffee is remarkably thin and limpid. The grain-infusion generally contains starch, and gives a blue coloration with iodine, whereas the infusions of both coffee and chicory appear to be quite destitute of starch.

2. *Colouring Power.*—Chicory and the allied roots impart to water a much deeper colour than coffee, the coloration being also much more rapidly produced. By infusing equal quantities of the several substances with boiling water, and observing the colour of the filtered infusions in glass tubes of equal diameter, it was found:—if the colouring power of caramel be represented by 1000, that of chicory is 450, of maize 350, of dandelion-root 300·3, of red beet 300·3, of bread-raspings 274·72, of acorns 200, of highly-roasted coffee 173·31, of medium-roasted coffee 143·88, of peas 73·18, and of brown malt 25. Hence it appears that chicory has more than three times the colouring power of highly-roasted coffee; maize double that of coffee; whereas peas and beans have only about half the colouring power of coffee.

In infusions prepared with cold water, chicory exhibits four times the colouring power of coffee. If a few grains of roasted chicory or any other sweet root be dropped into a glass of cold water, without being stirred, a yellowish-brown colour diffuses rapidly through the liquid, whereas pure coffee gives no sensible colour to the water under similar circumstances.

3. *Specific Gravity of the Infusions.*—Coffee is sharply distinguished from the two most important classes of adulterating substances, the roots and cereals, by the comparatively low specific gravity of its infusion. The comparison may be made by dissolving 1 pt. of the substance in 10 pts. of cold water, raising the temperature to the boiling point, keeping it there for about half a minute, and then filtering. The leguminous seeds give infusions of low specific gravity: peas 1007·3, beans 1008·4. The specific gravity of coffee infusions varies from 1008·0, for Mocha, to 1009·5, that of Costa Rica coffee; that of chicory infusion is much higher, ranging in different samples from 1019·1 to 1023·2. Infusions of cereals stand equally high, or higher, in the scale of gravity, rye-meal giving 1021·6, and maize 1021·5.

4. *Action of Ether.*—The following substances, agitated with ten times their weight of ether, give different proportions of matter soluble in that liquid, viz.:

Roasted beans	1·81	per cent. of oil and resin,
" maize	5·15	" " "
" chicory (Yorkshire) . .	6·83	" " "
" coffee (Mocha) . . .	15·93	" " "

the last including probably 1 per cent. of caffeine. Hence it appears that coffee yields to ether much more soluble matter than beans, maize, or chicory, which represent the three classes of leguminous seeds, cereals, and sweet roots. The fat obtained from chicory was doubtless that which is added in the roasting process, to prevent burning. The experiment with ether is easily made, and may sometimes prove valuable.

5. *Quantity of fermentable Sugar.*—The quantity of fermentable sugar in sweet roots, both before and after torrefaction, is much greater than in coffee. By subjecting the different substances to fermentation with yeast, and determining the amount of alcohol in the distillate (see Sugar), the sugar in raw coffee is found to vary from 6·20 to 7·52 per cent.; that of roasted coffee from 0·0 to 1·14. The proportion in chicory and other sweet roots is given in the following table:

	Sugar per cent.	
	Raw.	Roasted.
Foreign chicory	23·76	11·98
Guernsey "	30·49	15·96
English "	35·23	17·98
" " (Yorkshire)	32·06	9·86
Mangold-wurzel	23·68	9·96
Carrots (ordinary)	31·98	11·53
Turnips	30·48	9·65
Beetroot (red)	24·06	17·24
Dandelion root	21·96	9·08
Parsnips	21·70	6·98
Bonka (a coffee substitute)	—	5·82

These numbers are sufficient to show that the fermentation-test affords an easy method of distinguishing these roots from coffee. The leguminous seeds, cereals, and other seeds are not so easily distinguished by this method, the proportion of sugar in the roasted material varying only from 0·74 in lupine seed to 2·70 in acorns.

6. *Composition of the Ash.*—Coffee is remarkably distinguished from the roots and cereals by the small quantity of silica in its ash, which never exceeds 0·5 per cent.; and even this small quantity, which is not always present, probably arises from accidental adhesion of sand to the beans. Chicory-ash, on the other hand, contains (after deducting sand) from 3·81 to 10·52 per cent. silica (i. 962), and roasted dandelion-root 11·26 per cent. The proportion of silica may be determined, without making a formal analysis of the ash, by simply digesting it in strong hydrochloric acid and weighing the residue. In lupines, acorns, maize, and parsnips, the proportion of silica is not large enough to afford a good distinction from coffee; but lupine-ash contains 17·75 per cent. of soda, which, according to Graham, Stenhouse, and Campbell, is not found in coffee-ash; the ashes of lupines and of acorns likewise contain twice as much chlorine as coffee-ash, and in the ash of maize the proportion of phosphoric acid is very high, viz. 44·5 per cent., whereas in coffee-ash it is only about ten per cent. Beetroot ash is distinguished from coffee-ash by its very large amount of chlorine, which varies from about 8 to 29 per cent.

7. *Proportion of Nitrogen.*—The nitrogen in foreign raw chicory amounts to 1·51 per cent. in the roasted root to 1·42 per cent. English chicory gave, in the raw state 1·86, in the roasted state 1·74 per cent. nitrogen. In roasted coffee the proportion of nitrogen is rather greater, viz. about 2·75 per cent.; but the difference is not great enough to afford a good mode of distinction. It may, however, be admitted that less than 2 per cent. of nitrogen in coffee is a strong presumption of adulteration with chicory or some other root.

On the whole, we may conclude that the best indication-tests of the presence of foreign substances in ground coffee are afforded by the colouring power, the specific gravity of the infusion, the fermentation-test, and the composition of the ash.

COFFEE LEAVES. The leaves of the coffee tree have been examined by Stenhouse (Phil. Mag. [4] vii. 21), who received a sample of them, dried at rather too high a temperature, from Sumatra. They were found to contain 1·2 per cent. caffeine, and altogether 2·1 per cent. nitrogen; as some of the caffeine may have been decomposed in the drying of the leaves, the real proportion may perhaps amount to 1·5 per cent. They also appear to contain a larger proportion of caffetannic acid than the beans; the proportion of matter extracted by water was 38·8 per cent. An infusion of the leaves in boiling water has a deep brown colour, and in taste and odour resembles a mixture of tea and coffee. The leaves might therefore, perhaps, be used as a substitute for tea-leaves or coffee-beans. Their use for this purpose was first suggested by Van den Corput in Brussels. (Ann. Ch. Pharm. lxxxix. 244.)

COFFEINE. Syn. with Caffeine (i. 707).

COGNAC. The finest kind of French brandy distilled from wine; it takes its name from the town of Cognac, in the Département de la Charente. (See BRANDY, i. 652.)

COHOBATION. The continuous redistillation of the same liquid from the same materials.

COHESION and **ADHESION.** Cohesion is the force by which particles of one and the same body, or homogenous particles in general, are held together. Adhesion that which holds together the particles of two dissimilar bodies when brought into close contact.

These forces appear to act only at distances inappreciable to our senses. When a solid body, as a piece of wood or stone, is broken, the pieces cannot be made to cohere again by merely pressing them together, because the surfaces, being uneven, can only come into contact at a few points, and the cohesive force is imperceptible; but if the bodies touch each other by large flat surfaces, as when two well polished plates of glass or metal are pressed together, they cohere with great force.

The adhesion between the particles of dissimilar bodies is determined by precisely similar conditions. Plates of lead and tin, or of copper and silver, may be almost inseparably united by strong pressure between rollers. Adhesion takes place with peculiar facility when one or both of the bodies is in the liquid state, because the particles, being free to move, can easily adapt themselves to each other. All liquids, like oil and water, which do not mix, adhere with more or less force by their surfaces, and adhesion shows itself in most cases when a liquid comes in contact with a solid body, the liquid being then said to wet the solid. A glass plate suspended from the arm of a balance and made to touch the surface of water requires considerable force to separate it. If the liquid which adheres to the surface of the solid afterwards solidifies, the adhesion becomes still stronger: this is the principle of cementing. When two glass plates are joined together with sealing wax, the adhesion is sometimes so strong that in attempting to part them, particles of the glass separate from each other rather than from the wax.

Notwithstanding the great difference which appears to exist between these molecular forces, and that of gravitation, the former acting only at insensible, while the latter acts at all distances, it is not difficult to show that both kinds of attraction may be merely different modifications of the same power. Let it be assumed that all ultimate atoms attract one another with forces varying directly as their masses and inversely as the squares of the distances between them, and that the aggregates of atoms constituting the physical molecules are not spherical, at least not in all cases. The law of molecular attraction will then depend in great part on the forms and dimensions of these molecules. The attraction between spheres composed of particles which attract one another according to the law of the inverse squares, is the same as if the whole matter of each sphere were concentrated in its centre, that is to say, the spheres attract one another inversely as the square of the distance between their centres. But in bodies of any other shape, the attraction may be regarded as consisting of two parts, one following the law of the inverse squares, just as if the bodies were spherical, the other dependent on the shape of the bodies, and varying inversely as the cube of the distance between their centres of gravity. Such is the case with the attraction of the earth and moon. The equatorial protuberance of the earth produces certain perturbations in the relative movement of the two bodies, which vary in magnitude according to the law last stated, and would become much more perceptible if the earth and moon were nearer to each other, but would vanish if the distance between them were much greater than it is: for example, if the distance were diminished to $\frac{1}{10}$ of its present amount, the principal part of the attractive force, which determines the elliptical motion, would be increased 100 times, but the disturbing force depending on the figure would be increased 1000 times. If then the law of attraction between the molecules of bodies be affected in like manner by their figures, it will follow that at the extremely small distances existing between the particles of a solid body or of two bodies pressed closely together, the molecular force, which determines the phenomena of cohesion and adhesion, may become almost immeasurably greater than when they are separated by any appreciable distance: for the molecules are so minute that the smallest distance appreciable to our senses may be regarded as infinitely great compared with their dimensions, so that it is only at insensible distances that the influence of their form makes itself felt.

The force of cohesion varies with the temperature and the nature of the body. In gases, in which the dimensions of the actual material particles must be supposed to be infinitely small as compared with the intervals between them, the cohesive force is little, if at all perceptible; in fact, the particles of gases have a constant tendency to fly asunder. (See GASES and HEAT.)

In **liquids**, the distance between the particles is still sufficiently great, compared with their size, to give great freedom of motion, but not sufficient to render the molecular attraction depending on the form of the particles imperceptible; hence liquids, though their particles yield with ease to any external force, nevertheless exhibit, when left to themselves, a tendency to assume the spherical form, that being the arrangement in which a given number of particles occupy the smallest space; since, however, the liquid mass is subject to the influence of other forces, as gravitation and adhesion, the spherical form of a drop is never perfect; this may be seen in the form which drops of mercury assume on glass, or water on glass smeared with fat or lycopodium. As the temperature rises, the cohesive force becomes less, in consequence of the greater separation of the particles; consequently a heated liquid generally forms smaller drops than a cold one. Different liquids exhibit different degrees of cohesion, the cohesive power being very nearly proportional to the density.

In **solids**, the cohesive power shows itself in the highest degree, the particles not being able to move freely over one another, so that an external force, if it does not produce disruption, gives rise to an equal and parallel motion throughout the mass.

The force of cohesion in a solid is measured by the resistance which the body offers to any mechanical force tending to separate the particles. The resistance offered to a force tending to pull the particles asunder is called the **absolute cohesion** or **tenacity**; the lateral resistance to fracture is the **relative tenacity**; and the resistance which the body opposes to a crushing force is sometimes called the **retroactive tenacity** (*rückwirkende Festigkeit*). These three modifications of the cohesive strength have all been made the subject of direct experiment in numerous bodies; they are connected with each other by relations which are capable of exact mathematical analysis, but the investigation of which is foreign to the character of this work.

Absolute tenacity—Muschenbroeck made numerous experiments on the absolute tenacity of bodies; his results are given in the following table, which shows the weights required to break rods or wires of various materials when suspended from them:—

Absolute Tenacities of Solids

	Horizontal section = ¼ square line.		Horizontal section = ¼ sq. centimetre.	
Elm-wood	87	pounds	918	kilogr.
Pine (*Pinus silvestris*)	97	„	1021	„
Fir (*Pinus abies*)	57—88	„	600—929	„
Oak	110—140	„	1150—1466	„
Beech	136—148	„	1349—1586	„
Ebony	89	„	934	„
Copper wire	266	„	2782	„
Brass	340	„	3550	„
Gold	442	„	4645	„
Lead	26	„	272	„
Tin	43	„	457	„
Silver	326	„	3411	„
Iron	398	„	4182	„
Glass (white)	14—22	„	142—233	„
Hempen cord	34—60	„	350—360	„

The great variation in the strength of hempen cord arises from the unequal quality of the fibre. Thin cords are comparatively stronger than thick ones, because they are made of better hemp.

The number for gold in the above table is doubtless too high. According to Count Sickingen, the tenacities of different metals are to one another in the following proportions:—

Gold	150955	Copper	304696
Silver	190771	Soft iron (Swedish)	362927
Platinum	262361	Hard iron	559880

The following table exhibits the absolute tenacities of different metals at the temperatures of 0°, 100°, and 200° C., as determined by **Baudrimont** (Ann. Ch. Phys. [3] xxx. 304.) The upper number opposite each metal gives the highest tenacity observed; the lower number the mean of each set of experiments:

Metals.	Tenacity in grammes for a transverse section of 1 mm. at		
	0°	100°	200°
Gold	19051 18400	15766 15224	13094 12878
Platinum	23026 22625	20421 19284	18118 17277
Copper	25338 25100	22050 21873	19839 18215
Silver	28620 28324	24526 23266	18705 18577
Palladium	36983 36481	32871 32484	29212 27077
Iron	209813 205405	201039 191725	213305 210270

These numbers show that the tenacity diminishes for the most part as the temperature rises; iron, however, exhibits an exception, being more tenacious at 200° than at 100° C.

Resistance to crushing.—The following table is the result of experiments by George Rennie, jun., published in the first part of the *Philosophical Transactions* for 1818. Mr. Rennie found a cubic inch of the following bodies crushed by the following weights:—

	Crushing weight in lbs. av.
Elm	1284
American pine	1606
White deal	1928
English oak	3860
A prism of Portland stone, 2 inches long	805
Ditto statuary marble	3216
Craigleith stone	8688

Cubes of 1½ *inch.*

	Sp. gr.	
Chalk	—	1127
Brick of a pale red colour	2·085	1265
Roe-stone, Gloucestershire	—	1449
Red brick, mean of two trials	2·168	1817
Yellow-face baked Hammersmith paviors, three times	—	2254
Burnt ditto, mean of two trials	—	3243
Stourbridge, or fire brick	—	3864
Derby grit, a red friable sandstone	2·316	7070
Derby grit from another quarry	2·428	9776
Killala white freestone, not stratified	2·423	10264
Portland	2·428	10284
Craighleith white freestone	2·452	12346
Yorkshire paving, with the strata	2·507	12856
Ditto, against the strata	2·507	12856
White statuary marble, not veined	1·760	23632
Bramley-Fall sandstone, near Leeds, with strata	2·506	13632
Ditto, against strata	2·506	13632
Cornish granite	2·662	14302
Dundee sandstone, or breccia, two kinds	2·650	14918
A two inch cube of Portland	2·423	14918
Craighleith, with strata	2·452	15560
Devonshire red marble, variegated	—	16712
Compact limestone	2·584	17354
Peterhead granite, hard close-grained	—	18636
Black compact limestone, Limerick	2·598	19924
Purbeck	2·599	20610
Black Brabant marble	2·697	20742

Cubes of 1½ inch (continued).

	Sp. gr.	Crushing weight in lbs. av.
Very hard freestone	2·528	21254
White Italian veined marble	2·725	2178°
Aberdeen granite, blue kind	2·625	24556

Cubes of different metals of ¼ inch were crushed by the following weights: —

	lbs. av.
Cast iron	9773
Cast copper	7318
Fine yellow brass	10304
Wrought-copper	6440
Cast tin	966
Cast lead	483

Bars of different metals, 6 inches long, and ¼ of an inch square, were suspended by nippers, and broken by the following weights: —

	lbs av.
Cast iron, horizontal	1166
Ditto, vertical	1218
Cast steel, previously tilted	8391
Blistered steel, reduced by the hammer	8322
Shear steel, ditto	7977
Swedish iron, ditto	4504
English iron, ditto	3492
Hard gun-metal, mean of two trials	2273
Wrought copper, reduced by hammer	2112
Cast copper	1192
Fine yellow brass	1123
Cast tin	296
Cast lead	114

On the tenacity and other mechanical properties of *cast iron*, a large number of experiments were made by Stephenson, Fairbairn, and Hodgkinson, in connection with the construction of tubular bridges (*The Britannia and Conway Tubular Bridges*, by Clarke, London, 1850; Ann. Min. [4] xx. 427). The experiments on the resistance to direct tension, gave for the absolute tenacity of cast-iron a mean value of 10 to 11 kilogrammes for a square millimetre. The retroactive tenacity was found to be on the average 5·7 times greater than the absolute tenacity.

The tenacity of *glass* has been examined by Fairbairn and Tate (Proc. Roy. Soc x. 6). The absolute tenacity determined by direct stretching was found to be for:

	Tenacity per sq. in. in lbs.
Flint glass (best; specific gravity 3·0782)	2413
Green glass (specific gravity 2·5284)	2896
Crown glass (extra white; specific gravity 2·4504)	2346

But from experiments on the resistance of glass globes to internal pressures, much higher values were found for the absolute tenacities, viz. for:

	Tenacity in lbs.
Flint glass	4200
Green glass	4800
Crown glass	6000

These results are regarded by the authors as more trustworthy than the former, because the globes were better annealed than the rods used in the first experiments.

Experiments on the resistance of glass to crushing were made upon small cylinders and cubes crushed between parallel steel surfaces by means of a lever. The cylinders were cut from rods drawn to the required diameter while hot, and then annealed. The cubes were cut from much larger portions, and were probably less thoroughly annealed. For this reason, the experiments on cylinders, which gave nearly twice the resistance afforded by the cubes, are regarded as the more trustworthy. The following table gives the mean results:

Resistance of Glass to Crushing.

	Mean crushing weight in lbs. per sq. inch.	
	For cylinders.	For cubes.
Flint glass	27582	13130
Green glass	31876	20206
Crown glass	31003	21762

COLCHICEINE, $C^{34}H^{42}N^2O^{11}$ (Oberlin, Ann. Ch. Phys. [3] l. 108).—An alkaloïd prepared from colchicine by acidulating the aqueous solution of that body with sulphuric or hydrochloric acid, concentrating the liquid to dryness over the water-bath, then adding water, and crystallising from alcohol the yellow mass which separates. At the same time there is produced, by the action of the acid on the colchicine (perhaps impure), a resin which dissolves in alcohol and in ether, and with deep red colour in ammonia or nitric acid. According to Oberlin, colchiceine exists ready formed in the seeds of *Colchicum autumnale.*

Colchiceine crystallises in colourless nacreous laminæ or needles, sparingly soluble in cold, more easily in boiling water, easily soluble in alcohol, wood-spirit, and chloroform. It melts at 155° C. and becomes coloured at 200°. It dissolves with deep-yellow colour in strong nitric acid; without colour in sulphuric, hydrochloric, and acetic acid. It is insoluble in alkalis, appears to unite with baryta, is coloured green by ferric chloride. The alcoholic solution is not precipitated by lead-salts, platinic or mercuric chloride, nitrate of silver, or tincture of galls.

Colchiceine exerts, sometimes at least, a poisonous action when injected into the stomach. Oberlin states (Compt. rend. liii. 1202), that 0·1 grm. killed rabbits in 12 hours, and 0·05 grm. in a few minutes; but according to another account (Ann. Ch. Phys. [3] l. 114), even 0·5 grm. produced only temporary symptoms.

COLCHICINE. This alkaloïd, which is contained in all parts of the *Colchicum autumnale*, and probably also in other species of *colchicum*, was discovered by Pelletier and Caventou (Ann. Ch. Phys. [2] xiv. 69), who however regarded it as identical with veratrine. It was further examined by Geiger and Hesse, who first, in 1833, (Ann. Ch. Pharm. vii. 274) recognised its separate identity, and has been more recently investigated by Hübschmann (Arch. Pharm. [3] xcii. 330), Aschoff, *ibid.* lxxxix. 4), Bley (*ibid.* 18), and others.

Preparation.—1. The bruised seeds of colchicum are macerated with alcohol containing sulphuric acid; the extract is treated with lime; the filtered liquid saturated with sulphuric acid; and the alcohol expelled by distillation. The concentrated aqueous solution is then decomposed with carbonate of potassium; the precipitate is dried, and dissolved in absolute alcohol; the solution is decolorised with animal charcoal; the filtered liquid is evaporated at a gentle heat; and the alkaloïd thus obtained, is purified by repetition of the treatment with alcohol and animal charcoal (Geiger and Hesse).—2. According to Hübschmann, a larger product is obtained by exhausting the seeds with 3½ pts. alcohol of 90 per cent.; then distilling off the alcohol, precipitating the residual liquid with carbonate of potassium; exhausting the dried precipitate with ether, and finally with sulphuric acid, to separate resin; and reprecipitating with carbonate of potassium.—3. Aschoff boils the comminuted seeds with water, neutralises the decoction with lime-water; filters after boiling, and evaporates to the consistence of an extract; then exhausts the extract with alcohol, continuing the process as long as the alcohol acquires thereby a bitter taste. The residue left after the distillation of the alcohol, is dissolved in water and precipitated with tannic acid; the precipitate is washed and pressed, then dissolved in alcohol, and digested with a sufficient quantity of recently precipitated ferric hydrate at 30° C.; lastly, the filtrate is evaporated, and the residue treated with absolute alcohol, which dissolves out the pure colchicine.—4. Polex exhausts the bruised seeds with a mixture of 4 pts. ether and 1 pt. alcohol, evaporates to dryness, dissolves the residue in water, and purifies the dissolved alkaloïd with animal charcoal.

Bley and Aschoff, obtained from the seeds, as a maximum, 0·2 per cent. of colchicine.

Colchicine may likewise be prepared by similar processes from the flowers, leaves, and bulbs of the plant.

Properties.—Colchicine crystallises from its alcoholic solution, on addition of water, in colourless prisms and needles: the alcoholic or ethereal solution leaves it, on evaporation, in the form of a transparent varnish (Geiger). According to other chemists, colchicine is always obtained as an amorphous yellowish white powder. It has a persistently bitter taste, not burning like that of veratrine; it is inodorous, and does not like veratrine, excite sneezing. According to Geiger, it has a very faint alkaline reaction, reddening rhubarbarin, and bluing reddened litmus paper. According to Bley, Aschoff, and Hübschmann, on the contrary, it is perfectly neutral. It is permanent in the air.

The composition of colchicine has not been satisfactorily determined. According to Bley, it contains 55·0 per cent. C, 7·4 H, and 13·0 N, which he represents by the empirical formula $C^{37}H^{26}N^{3}O^{11}$, although his results agree better with $C^{30}H^{23}N^{3}O^{10}$, or $C^{15}H^{12}N^{2}O^{5}$. Aschoff found 55·2 C, 6·2 H, and 2·8 N, whence he deduces the formula $C^{23}H^{21}NO^{11}$. The great difference in the nitrogen determinations, and certain differences in the properties of the base, as observed by these two chemists, seem to show that they must have been operating, either upon different bases, or on the same in very different degrees of purity.

Colchicine dissolves with moderate facility in water, according to Hübschmann, in less than 2 pts. at 22° C.; this property distinguishes colchicine from veratrine, which is insoluble in water. It dissolves easily in alcohol, less easily in pure ether; at 20° C., in 18 pts. ether of specific gravity 0·74. Chloroform dissolves it readily, and withdraws it for the most part from the aqueous solution on agitation.

Colchicine, when strongly heated, melts and decomposes with intumescence (according to Bley, it volatilises at 112° C.). Strong nitric acid colours it deep violet or blue, quickly changing to olive-green and yellow; strong sulphuric acid colours it yellowish-brown, not violet, thus affording a distinction from veratrine. Phosphoric acid and hydrochloric acid colour even dilute solutions of colchicine distinctly yellow; chromic acid colours the solution green. Chlorine-water renders the solution turbid, and on subsequently adding ammonia, it assumes a yellowish-red colour. Colchicine is precipitated of a kermes-brown colour from its aqueous solution by tincture of iodine; yellow by dichloride of platinum, white by tannic acid, the last-mentioned precipitate being soluble in alcohol, acetic acid, and alkaline carbonates.

The statements of different chemists regarding the behaviour of colchicine with bases and acids do not agree. According to Aschoff, colchicine is converted by caustic alkalis into a brown resinous mass, soluble in water and alcohol; it unites with baryta and lime, but does not decompose alkaline carbonates. According to Bley, a solution of colchicine mixed with carbonate of soda, yields by evaporation a non-crystalline mass, free from carbonic acid (?).

According to Geiger, colchicine neutralises acids completely, forming extremely bitter salts, with rough irritating after-taste; some of them, the sulphate for example, are crystallisable and permanent in the air. They are very soluble in water and in alcohol, the aqueous solutions yielding with iodine and with tincture of galls the same reactions as the pure base; caustic alkalis precipitate the colchicine from concentrated, but not from dilute solutions of the salts Bley and Aschoff did not succeed in preparing crystallisable compounds of colchicine with acids. The salts were acid, and soluble in water and alcohol, excepting the tannate, which is insoluble in water.

Physiological action.—Colchicine is poisonous, even small doses causing violent vomiting and purging; $\frac{1}{18}$th of a grain killed a cat in twelve hours. Tannin is said to be a good antidote. In cases of poisoning by colchicine, the alkaloïd may be detected by treating the stomach and intestines with strong alcohol, evaporating the liquid, and again treating the residue with alcohol, or with alcohol and ether, and again evaporating. Colchicine then remains as an amorphous yellowish mass, which exhibits the above-mentioned reactions with mineral acids, tincture of iodine, and tannic acid.

COLCHICUM AUTUMNALE. The root and seeds of this plant are used in pharmacy; according to Coindot, however, the flowers are more active and to be recommended for the preparation of a tincture.

The flowers, according to Reithner, contain colchicine in combination with tannic acid, also sugar, pectin, gum, fat, wax, and resin. The dried flowers, without anthers, yield 4·05 per cent. ash (*a*); the dried anthers alone yield 4·15 per cent. ash (*b*), containing in 100 parts:

	a.	*b.*		*a.*	*b.*
Potash	37·4	40·0	Silicic acid (anhydrous)	7·7	0 8
Soda	8·5	6·1	Carbonic „	22·3	22·5
Lime	4·3	2·6	Sulphuric „	3·7	6·2
Magnesia	3·0	6·5	Phosphoric „	10·6	14·4
Alumina	0·3	trace	Chlorine	1·5	0·5
Ferric oxide	0·5	0·2			

The ripe seeds collected in July contain in 100 pts., according to Bley: 0·2 colchicine, 5 glucose, and 6 fixed oil, together with resin, extractive matter, cellulose, and traces of veratric acid and gallic acid.

The fresh bulbs contain, according to the same authority, 0·2 per cent. colchicine, 0·3 sugar, 0·5 colouring matter, 29·0 starch, together with gallic acid, extractive matter, cellulose, &c. Colman found also 21 per cent. starch. The starch may be extracted from the bulbs by washing with water; after prolonged washing, it is perfectly pure and tasteless. (Handw. d. Chem. ii. [3] 153).

COLCOTHAR VITRIOLI, also called *Crocus Martis*.—The brown-red oxide of iron which remains after the distillation of sulphuric acid from sulphate of iron; it is used as a polishing powder.

COLLETIIN. A crystallisable bitter principle, obtained from *Colletia spinosa* (order *Rhamnaceæ*). It forms needles insoluble in cold water and ether, sparingly soluble in boiling water, easily in alcohol. It is contained in the alcoholic tincture of the plant, which, according to v. Martius, is used in Brazil as a remedy for intermittent fever. (Handw.)

COLLIDINE. $C^8H^{11}N$.—An alkaloïd found, together with many others, among the products of the dry distillation of animal substances and of coal. It was discovered by Anderson in 1855 (Phil. Mag. J. [4] ix. 145, 214), who obtained it from bone-oil, and was afterwards found by Greville Williams in the bituminous shale of Dorsetshire (Chem. Soc. Qu. J. vii. 97), in coal tar, and in the impure quinoline obtained by the dry distillation of quinine and cinchonine (Chem. Gaz., 1855, p. 308). It is isomeric with ethyl-phenylamine, ethyl-picoline, dimethyl-phenylamine, and xylidine.

Preparation.—1. The portion boiling above 170° C. of the mixture of volatile bases obtained from bone-oil (i. 625), is mixed with a considerable quantity of strong nitric acid, which acts very violently upon it, thereby acquiring a deep red colour, and on boiling evolves nitrous acid fumes and an odour of bitter almonds. The part boiling at 182° C. must be well cooled while being mixed with the nitric acid, to prevent explosion. The acid solution, when mixed with water, becomes turbid, from the separation of a reddish-yellow oil, which seems to be impure nitro-benzene; the acid solution is filtered through moist paper, and the filtrate is boiled for some time to expel the last traces of the neutral oils, then saturated with potash and distilled. The oil which passes over with the water is repeatedly rectified, and the portion boiling between 178° and 180° is collected. The part of the mixture of bases boiling above 170° contains a considerable quantity of phenylamine, which cannot be removed, either by repeated rectification or by recrystallisation of the oxalate; by the action of nitric acid it is destroyed, whilst the alkalis homologous with collidine remain undecomposed.—The part boiling between 172°—180°, when treated in this manner, yields, by distillation with potash, an oil which begins to boil at 160°, and is composed for the most part of lutidine; while the portion boiling above 180° yields an oil, the greater part of which goes over at 179°, and when rectified yields pure collidine. (Anderson.)—2. When the mixture of chinoline with other bases, which is obtained by the distillation of cinchonine with potash, is subjected to oft-repeated fractional distillation, the portion boiling between 177° and 182° C. yields, with solution of platinum, chloroplatinate of collidine. This salt may also be obtained from the fraction boiling between 182° and 187°, if another base mixed with it has previously been destroyed by means of nitric acid. (Gr. Williams.)

3. Gr. Williams mixes the naphtha obtained by the distillation of the bituminous shale of Dorsetshire with sulphuric acid; boils with water until all the tar is converted into resin, and all the pyrrol is removed; concentrates the liquid; neutralises with lime or potash, and distils; supersaturates the distillate with hydrochloric acid; removes the non-basic oil; then supersaturates the acid liquid with lime or potash, and distils. The distillate is freed from ammonia by washing with strong potash, dried by solid hydrate of potash, and fractionally distilled until liquids of constant boiling points are obtained. The small portion which passes over between 132° and 138° C. is lutidine mixed with a little picoline (from the mother-liquor of the chloroplatinate of lutidine, the double salt of picoline is obtained); the portion obtained between 149° and 155°, and between 177° and 182° is pure lutidine; and that which passes over between 227° and 258° is collidine.—4. The mixture of volatile bases obtained in like manner from coal-tar oil is treated, as in Anderson's process, with nitric acid, and subjected to repeated fractional distillation. The portion which distils between 150° and 155° C. is lutidine, and afterwards a small quantity of collidine passes over. (Gr. Williams.)

Properties.—Collidine is a colourless, oily liquid, having a strongly aromatic, not unpleasant odour. Specific gravity, 0·921; boiling point, 179° C. It forms white fumes when a glass rod moistened with hydrochloric acid is held over it. It is insoluble in *water*, but takes up a small quantity of that liquid, which it gives up again to hydrate of potassium. It dissolves readily in *alcohol*, *ether*, and *oils*, both fixed and volatile.

Collidine dissolves readily in *acids*, but does not neutralise them. It does not precipitate the salts of barium, calcium, magnesium, manganese, or nickel, but throws down alumina, chromic oxide, oxide of zinc, ferric oxide, and mercurous oxide from their solutions: it also precipitates nitrate of lead, but not the neutral acetate. (Anderson.)

Chloromercurate of Collidine is obtained as a white, curdy, flaky precipitate, and crystallises from hot water in needles. The *chloroplatinate*, $2(C^8H^{11}N.HCl).PtCl^4$, forms orange-yellow flakes. (Anderson.)

Ethyl-collidine, $C^{10}H^{15}N = C^8H^{10}(C^2H^5)N$.—The hydriodate of this base is obtained as an oily liquid by heating collidine to 100° C. with iodide of ethyl. On decomposing it with nitrate of silver, removing the excess of silver by hydrochloric acid, and mixing the filtered liquid with tetrachloride of platinum, the *chloroplatinate* $2(C^{10}H^{15}N.HCl).PtCl^4$ is obtained, as a finely-divided, crystalline, sparingly soluble precipitate (Anderson, Phil. Mag. [4] ix. 221).

COLLINIC ACID. $C^6H^4O^2 = \left.\begin{matrix}C^6H^3O\\ H\end{matrix}\right\}O$. (Fröhde [1860], J. pr. Chem. lxxx. 344).—An acid belong to the aromatic series $C^nH^{2n-8}O^2$, found among the products of the oxidation of the albuminoïdal substances, and of gelatin. To obtain it, the mixture of acids produced by oxidising gelatin with chromic acid is saturated with carbonate of sodium, and evaporated to drive off the neutral volatile bodies; the nearly dry salts are decomposed by sulphuric acid; and the solid acid thereby separated is filtered and washed. If the residue be then treated with a small quantity of boiling water, the greater part of the collinic acid remains in fused reddish masses (about 0·96 grm. collinic acid from 1 kilogrm. gelatin), while the other acids, especially the benzoic acid, dissolve completely, together with a small portion of the collinic acid. By recrystallisation from water, it may be obtained in small crystals having a prismatic aspect.

Collinic acid has a sour, pungent taste; dissolves sparingly in boiling water, easily in ether. When heated with water, it melts at 97° C, and then solidifies at 93° or 94$^{\text{C}}$; in the dry state, it does not melt till heated somewhat above 100°. On cooling, is solidifies to a waxy mass generally having a radiate texture. At a higher temperature, it sublimes. When set on fire, it burns with a bright but smoky flame. Boiled with carbonate of sodium, it yields humoïd flakes. Heated with hydrate of potassium, it decomposes, but does not appear to yield any volatile acids.

Collinic acid is a strong acid, dissolving in caustic alkalis, and decomposing carbonates. It forms both neutral and basic salts. The silver-salts decompose with facility.

A solution of *collinate of ammonium* gives off ammonia and becomes acid on boiling; acid vapours, however, escape at the same time. The *barium salt*, $C^{12}H^6Ba''O^4$ + aq., is crystalline, easily soluble in water, gives off water of crystallisation when heated, melts and blackens at a higher temperature. The *ferric salt* is a light, yellowish-red precipitate, which dissolves with blood-red colour on addition of a small quantity of acid. The *neutral silver-salt*, $C^6H^3AgO^2$, is obtained in crystalline scales by precipitating the ammonium-salt with nitrate of silver, dissolving the precipitate in water, and evaporating over oil of vitriol. The mother-liquor when evaporated gives off acid and yields grey granules of a basic salt, $Ag^2O.2C^6H^3AgO^2$; by continued heating of the solution, the silver-salt is reduced.

An acid isomeric, if not identical with collinic acid, is produced by oxidising coal-tar naphtha with dilute nitric acid (De La Rue and Müller, Chem. Soc. Qu. J. xiv. 54), or sulpho-benzolic acid with chromic acid. (Church, *ibid.* 53.)

COLLINIC ALDEHYDE. *Hydride of collyl.*—This compound occurs, according to Fröhde (J. pr. Chem. lxxx. 325), among the neutral volatile products of the oxidation of the albumoïds, and of gelatin; it appears to have been previously noticed by Schlieper and Guckelberger. It is probably C^6H^6O (isomeric with phenic acid). It has not yet, however, been obtained pure, especially not free from hydride of benzoyl. It is a colourless viscid oil, smelling somewhat like oil of cinnamon, and turning yellow from oxidation when exposed to the air. By prolonged boiling with potash-ley, it is converted into collinic acid. By continued contact with ammonia, it is converted into a white crystalline substance, probably the homologue of hydrobenzamide.

According to Schlieper (Ann. Ch. Pharm. lix. 22), this oil having the odour of cinnamon is converted by the action of dry chlorine, with elimination of hydrochloric acid, into a white substance which is insoluble in ether, and when heated with potash-ley forms a blood-red volatile oil; the potassium-salt, on addition of an acid, emits the odour of phenic acid.

COLLODION (from κολλώδης, glutinous). A solution of pyroxylin (gun-cotton) in ether. The solubility of this substance in ether, varies considerably according to the mode of its preparation; the most explosive kinds are by no means the most soluble (see PYROXYLIN). The best mode of obtaining pyroxylin for the preparation of collodion, is to mix 16 pts. of nitrate of potassium with 12 pts. of common and 12 pts. of fuming oil of vitriol; immerse in this mixture, as soon as it is made, 1 pt. of cotton wool, stir it about for five minutes, and then wash it well with water.

To prepare collodion, pyroxylin obtained in the manner just described is shaken up with 16 pts. ether, in a bottle which can be closed. 1 or 2 pts. of absolute alcohol are added after a while, and the vessel shaken at intervals, till the solution is complete. Lassaigne pours 26 pts. of ether on 1 pt. of pyroxylin, and mixes the resulting jelly with 18 pts. more of ether. According to other methods, 1 pt. of pyroxylin is treated with from 20 to 120 pts. of ether, and from 4 to 16 pts. of alcohol. The solution obtained by either of these methods is left to stand till the undissolved parts have settled down.

Pyroxylin is said also to be rendered perfectly soluble in ether by moistening it with acetone.

Collodion is a clear colourless gummy liquid, insoluble in water and alcohol, but soluble in ether; when exposed to the air, it soon dries up, leaving a transparent or translucent residue, which becomes strongly electric by friction, explodes less easily by heat, pressure, or percussion than flocculent pyroxylin, and is soluble in ether containing alcohol and in strong acetic acid.

When the ethereal solution is suffered to evaporate in a thin film, it dries up quickly to a thin transparent membrane, which possesses great adhesiveness, is tolerably impervious to air, and is not dissolved either by water or by alcohol. These properties render collodion very useful for a variety of purposes. It is employed with great advantage in surgery to form an air-tight covering for wounds and burns; when spread over an incised wound, it greatly promotes the healing by drawing the edges of the wound together, the film of collodion contracting strongly as the ether evaporates. As the collodion film is rather solid, and has but little elasticity, it has been recommended to melt 2 grms. of Venice turpentine with 2 grms. castor oil and 2 grms. of white wax, mix the fused mass with 6 grms. of ether, and add the whole to 140 grms. of collodion.

Collodion is also used as an envelope for caustic substances, in order to confine their action exactly to the desired spot. Pills may be coated with it, so as to render them tasteless, and wood, paper, and other fabrics may be rendered water-proof by being covered with it.

Collodion is also largely used in photography. A thin layer of the solution, mixed with iodide, bromide, or chloride of potassium, or ammonium, is spread uniformly over a glass plate, then treated with a solution of nitrate of silver to form the sensitive film. It appears to be essential to use anhydrous ether and alcohol for the solvent, in order to insure uniform evaporation.

Another application of collodion is for making balloons. For this purpose, a solution of collodion, not too thick, is poured into a flask of suitable dimensions, which is turned about to spread the liquid uniformly over it, and then inverted to allow the excess to run out. The ether is now evaporated from the film of liquid which adheres to the glass, by blowing into the flask with a pair of bellows, whereby the collodion is left in the form of a thin membrane on the surface of the glass. To remove it, the edges of the film are loosened from the glass, a glass tube of suitable character is inserted into the neck of the flask, so that the balloon may adhere to it, and the air is slowly drawn out with the mouth; the balloon then detaches itself from the vessel, contracts, and is easily withdrawn through the neck. It must be immediately blown out and tied at the neck, so that it may dry in the distended state. Small and thin balloons do not diminish much in volume as they dry; but larger ones contract strongly: this contraction may, however, be prevented by drying the balloon in warm air. Collodion balloons may be made much lighter than those of gold-beater's skin, so that much smaller ones will rise in the air when filled with detonating gas (2 vol. H and 1 vol. O). They may be made so thin that a balloon containing 100 cubic centimetres shall weigh only 0·03 grms. when empty, and 0·04 when filled with hydrogen; now the weight of an equal volume of air is 0·13 grms., consequently such a balloon will rise rapidly in the air. Hydrogen diffuses quickly through their pores. Collodion balloons become strongly electric by slight friction; when very thin, they exhibit beautiful interference-colours. (Handw. d. Chem. ii. [2] 158).

COLLYL, HYDRIDE OF. See COLLINIC ALDEHYDE.

COLLYRITE. A hydrated silicate of aluminium, $2Al^4O^3.SiO^3 + 10aq.$, found at Ezquerra in the Pyrenees, near Schemnitz in Hungary, and near Wessenfels in Saxony. It is white, very soft, earthy, unctuous to the touch, adheres strongly to the tongue. In water it becomes transparent and crumbles to pieces: it dissolves in acids and the solution yields a jelly by evaporation (Gm. iii. 411.)

COLOCYNTHIN. A bitter substance contained in the pith or pulp of the fruit of *Cucumis colocynthis* (bitter apple), a plant growing wild in the Grecian Archipelago, also in Egypt, and other parts of North-eastern Africa. It has been examined by Vauquelin (J. Phys. lxxxiv. 338), Braconnot (J. Pharm. x. 416), Herberger

(*Buchner's Repert.* xxxv. 368), **Bastick** (Pharm. J. Trans. x. 289), and lastly by **Walz** (Arch. Pharm. xcvi. 241; xcix. 338), who regards it as a glucoside = $C^{56}H^{84}O^{23}$.

It is prepared from the pulp of the fruit separated from the seeds. Vauquelin exhausted the pulp with cold water, and evaporated the extract, the colocynthin then separating in oily drops, which solidified on cooling. **Lebourdais** (Ann. Ch. Phys. [3] xxiv. 58) precipitates the aqueous extract with neutral acetate of lead, and treats the filtered liquid with animal charcoal, which takes up both the colouring matter and the bitter principle. The charcoal is then washed with water. As long as the liquid which runs through it acquires a bitter taste, nothing but pure colocynthin is dissolved; and on again precipitating it with animal charcoal, boiling the charcoal with alcohol, and leaving the solution to evaporate, the colocynthin separates in small warty groups. Walz exhausts the fruit with alcohol of 0·840; evaporates; dissolves the extract in water; precipitates the filtrate with neutral and with basic acetate of lead; removes the lead from the filtered liquid by sulphuretted hydrogen; and precipitates the colocynthin by tannic acid. The precipitate, which becomes resinous on heating the liquid, is dissolved in alcohol; the tannic acid is precipitated with basic acetate of lead; the filtrate, freed from lead, is heated with animal charcoal; the liquid is again filtered and evaporated; and the dry residue exhausted with ether, which leaves the colocynthin undissolved.

Colocynthin is intensely bitter, and acts as a drastic purgative. It is soluble in water, alcohol, and ether. The aqueous solution is precipitated by chlorine; it also yields, with acids and with deliquescent salts, a viscous precipitate insoluble in water. The solution is also precipitated by acetate of lead and many other metallic salts.

Colocynthin boiled with acids is resolved, according to Walz, into sugar (7·7 per cent.) and **colocynthein**, $C^{44}H^{64}O^{13}$, which remains as a resinous mass, and may be purified by washing with water, solution in absolute ether, and evaporation.

COLOCYNTHITIN. A body contained, according to **Walz** (N. Jahrb. Pharm. ix. 225), in the alcoholic extract of bitter apple (see CUCUMIS). When this extract is treated with water, colocynthitin remains undissolved; and on treating this residue with ether, digesting the solution with animal charcoal, evaporating the filtrate, exhausting with hot absolute alcohol, and leaving the filtered liquid to cool, colocynthitin separates in white microscopic crystals. It is soluble in ether.

COLOMBIC ACID. An acid obtained by **Bödecker** (Ann. Ch. Pharm. lxix. 47), from colombo-root, the root of *Menispermum palmatum*, L., *Cocculus palmatis*, Dec. To prepare it, the alcoholic extract of the root is exhausted with water or lime-water, and the solution treated with hydrochloric acid. Colombic acid is then precipitated in white amorphous flakes, which are strongly acid, nearly insoluble in cold water, very soluble in alcohol, sparingly soluble in cold ether. By the evaporation of its alcoholic solution, it is obtained in the form of a yellow varnish.

The alcoholic solution of colombic acid is not precipitated by acetate of copper, but yields with neutral acetate of lead a copious white precipitate, which, when dried at 130° C. contains 30·53 per cent. lead oxide, agreeing nearly with the formula $3PbO.2C^{42}H^{44}O^{12}$. Dried at 100° C., it contains in addition $5H^2O$.

The acid itself, dried at 115° C., gave by analysis 66·64 per cent. C, and 6·29 H, agreeing nearly with the formula $C^{42}H^{46}O^{13}$, or $C^{42}H^{44}O^{12}.H^2O$.

COLOMBIN. *Colombo Bitter.* $C^{21}H^{22}O^7$. (**Wittstock** [1830], Pogg. Ann. xix. 298.—**Liebig**, *ibid.* xxi. 30.—**Bödecker**, Ann. Ch. Pharm. lxix. 39.)—A neutral substance which constitutes the active principle of colombo root. Bödecker prepares it by exhausting the root with alcohol of 75 per cent., drying the extract as completely as possible, dissolving it in water, agitating the solution several times with an equal volume of ether, decanting the ethereal liquid with a siphon, filtering, and evaporating off the greater part of the ether. The colombin then crystallises out, and is purified by rinsing it with cold ether, pressing it between bibulous paper, dissolving it in boiling absolute ether, and concentrating the solution to one-fourth of its bulk. The greater part of the colombin then separates out quite white, the rest remaining dissolved in the ether, together with the fat contained in the root. To free the colombin entirely from fat, it must be repeatedly crystallised from ether; when quite pure it will dissolve in acetic acid without separation of oil-drops.

Colombin crystallises in colourless prisms belonging to the trimetric system. Observed combination, $\infty P . \infty \bar{P} \infty . \infty \breve{P} \infty . \bar{P} \infty$. Inclinations of the faces, $\infty P : \infty P = 125° 30'$; $\infty P : \infty \bar{P} \infty = 152° 45'$; $\infty P : \infty \breve{P} \infty = 117° 15'$; $\bar{P} \infty : \bar{P} \infty = 176° 19'$; $\bar{P} \infty : \infty \bar{P} \infty = 123° 39·5'$; $\infty P : \bar{P} \infty = 119° 31'$. The faces are brilliant, but the crystals do not cleave in any direction (**G. Rose**, Pogg. Ann. xix. 441). Colombin is inodorous, very bitter, and perfectly neutral to vegetable colours. It melts at a gentle heat. It dissolves but sparingly in cold water, alcohol, and ether, but imparts to them a strong bitter taste. Boiling alcohol of specific gravity 0·835 dissolves from $\frac{1}{40}$

to $\frac{1}{10}$ of its weight of colombin. It dissolves to a small amount in volatile oils, and more freely in potash, whence it is precipitated by acids in its original state. Acetic acid dissolves it and deposits it in the crystalline state on evaporation. Strong sulphuric acid dissolves it with orange colour, gradually changing to deep red, and on adding water to the solution, brown flakes are deposited. Solutions of colombin are not precipitated by any metallic salts or by tincture of galls.

Colombin yields, according to the mean of Bödecker's analyses, 65·20 per cent. C and 5·98 H, the above formula requiring 65·3 C, 5·7 H, and 29·0 O. It does not form any definite compound, so that its atomic weight cannot be determined.

COLOMBO ROOT. The root of *Cocculus palmatus*, Dec., contains colombin, berberine, colombic acid (probably as colombate of berberine), besides starch, colouring matter, &c. The colombic acid and berberine may perhaps be formed from colombin by addition of the elements of ammonia (Bödecker):

$$\underset{\text{Colombin.}}{4C^{21}H^{22}O^{7}} + 2NH^{3} = \underset{\text{Berberine.}}{2C^{20}H^{17}NO^{4}} + \underset{\text{Colombic acid.}}{C^{42}H^{44}O^{12}} + 5H^{2}O.$$

The root acts with violence on the animal organism; a grain of the dry extract prepared with ether and freed by water from fat and wax, killed a rabbit when introduced into a wound. This active property appears to be due to the colombin. (Buchner.)

COLOPHANE. A constituent of icica resin (*q. v.*), containing, according to Scribe (Compt. rend. xix. 129), $C^{20}H^{30}O^{2}$. It is yellow, amorphous, easily soluble in alcohol, melts above 100° C., is insoluble in aqueous alkalis, and reacts neutral.

COLOPHENE. $C^{20}H^{32}$ or $C^{40}H^{32}$. (H. Deville, Ann. Ch. Phys. [2] lxxv. 66; [3] xxvii. 85.)—A hydrocarbon polymeric with oil of turpentine, obtained by distilling that oil with strong sulphuric acid, or by distilling hydrate of turpentine-oil with phosphoric anhydride. In either case, terebene ($C^{10}H^{16}$) passes over first; afterwards, when the heat rises above 210° C. colophene distils; it is purified from sulphur and a substance resembling colophony by repeated rectification, at last over antimonide of potassium. It may also be obtained by the rapid distillation of colophony, the product being purified in like manner.

Colophene is an aromatic oil, colourless by transmitted light, and exhibiting by reflected light a dark indigo-blue iridescence. Specific gravity, 0·940 at 9° C., 0·9394 at 25°. Boiling point between 310° and 315°. Vapour-density = 11·13 (probably only twice as great as that of oil of turpentine, therefore = 9·526). Refracting power = 1·517 (Becquerel and Cahours), 1·5212 (Deville). It has no action on polarised light.

Colophene absorbs *chlorine gas* without evolution of hydrochloric acid, becoming hot, and changing to a resin like colophony, which separates in yellow spherules from its solution in absolute alcohol. If, when the absorption of chlorine has ceased, the product be heated to fusion in the stream of chlorine, a large quantity of hydrochloric acid is evolved, and Deville's *chlorocolophene* = $C^{20}H^{24}Cl^{8}$ is formed, which however still contains a resin removable by alcohol, and when distilled, gives off hydrochloric acid, yields a distillate of colophene and hydrochlorate of colophene, and leaves charcoal.

Hydrochlorate of Colophene.—Colophene absorbs hydrochloric acid gas, with rise of temperature, and acquires an indigo-colour. The hydrochlorate gives up nearly all its hydrochloric acid when treated with chalk, and when distilled with baryta, yields Deville's *colophilene* = $C^{20}H^{32}$, which does not exhibit the dichroism of colophene, and has a refracting power for light = 1·5175. (Deville, Becquerel, and Cahours, Pogg. Ann. li. 427—433.)

Colophene from Camphor. (Claus, J. pr. Chem. xxv. 266.—When camphor is distilled with an equal weight of iodine, hydriodic acid is evolved, camphin passes over at 180° C., and charcoal, iodine, campho-creosote and colophene remain behind (i. 728). On increasing the heat, the two latter substances distil over as a bluish-green oil, which is deprived of its creosote odour by agitation with potash, but cannot be obtained quite pure, even by distillation over lime and finally over potassium.

It is a thick, yellowish oil, with violet iridescence, having a high boiling point, a mild taste, and an odour of violets, and burning with a bright fuliginous flame. It is perhaps identical with colophene from oil of turpentine or from colophony.

It is not soluble in *water* or in weak *alcohol*, but dissolves in *ether*, *oil of turpentine*, *rock-oil*, and *camphine*. When 2 drops of it are dissolved in 2 drachms of alcohol, the solution, after agitation with animal charcoal, exhibits a fine dark blue colour by reflected light.

COLOPHILENE. The hydrocarbon $C^{20}H^{32}$ obtained from Deville's hydrochlorate of colophene (*vid. sup.*)

COLOPHOLIC ACID of Unverdorben; *γ-resin of Colophony* of Berzelius. The constituent of colophony which is least soluble in alcohol, and is produced by the action of heat on pinic acid. It is therefore present in colophony in variable quantity, according as that substance has been more or less heated during fusion; the darker varieties contain about one-tenth. Colopholic acid is said to be likewise produced when pinic acid is distilled till a third of it has passed over.

Colopholic acid is brown, sparingly soluble in alcohol of 67 per cent., more readily in presence of pinic acid. It has a stronger affinity for bases than pinic acid; nevertheless the colopholates exactly resemble the pinates.

COLOPHONIC ACIDS. The resinous acids, pinic, pimaric, sylvic and colopholic, which are present in colophony.

COLOPHONITE. A variety of garnet, so called from its brown colour, resinous lustre, and easy fusibility. (See GARNET.)

COLOPHONONE. $C^{11}H^{18}O$. (Schiel, Ann. Ch. Pharm. cxv. 96).—An oil occurring among the more volatile products of the dry distillation of colophony; it is separated by fractional distillation. It is colourless, mobile, highly refractive, of specific gravity 0·84, boils at 97° C.; vapour-density about 5·1. When heated above its boiling point in a close vessel, it turns brown, and emits an odour of peppermint. It mixes with sulphuric acid, and on addition of water, a green oil separates, having an odour of thyme and rosemary. Hydrochloric acid acts in like manner; nitric acid converts it into a resin. With potassium, it gives off gas, and is converted into a brown mass, subsequently turning yellow.

COLOPHONY. *Rosin, Colophonium, Colophane, Arcanson, Brai sec, Geigenharz.* —The resinous substance which remains when turpentine or pine-resin is heated till the water and volatile oil are expelled. It is for the most part a mixture of several resinous acids, viz., pinic acid (the α-resin of Berzelius), which forms the principal part, sylvic acid (β-resin), and colopholic acid (γ-resin), sometimes also pimaric acid. These acids, which are mixed in various proportions, are all isomeric, their common formula being $C^{20}H^{30}O^{2}$ or $C^{40}H^{60}O^{4}$. They are perhaps formed by oxidation of turpentine oil:

$$2C^{10}H^{16} + O^{2} = C^{20}H^{30}O^{2} + H^{2}O.$$

Colophony is either pale yellow and transparent (*C. album*) or brownish-yellow and translucent (*C. commune*), according to the degree of heat to which it has been exposed. By distillation with steam under a pressure of about ten atmospheres, it may be obtained very nearly colourless (*Hunt and Pochin's Patent*, 1858, No. 925). It has a vitreous lustre, is brittle in the cold, has a conchoïdal fracture, and yields a yellowish powder. Its specific gravity varies from 1·07 to 1·08. It is insoluble in water, but dissolves easily in alcohol, ether, wood-spirit, and oils both fixed and volatile. Rock-oil dissolves only a portion of it; the undissolved part is said to be identical with pinic acid altered by the action of the air. Nitric acid dissolves and decomposes it at the same time.

Colophony, being a mixture of acids, unites with bases. The compounds which it forms with the alkalis are soaps soluble in water. It is easily saponified either by caustic alkalis or by their carbonates.

Colophony softens at 69° or 70° C. and melts at 135°. At a higher temperature it gives off volatile oils, acquiring a darker colour, and yields colopholic acid. When quickly heated in a retort, it distils partly undecomposed, partly resolved into gases, volatile oils, viz. Deville's terebene and colophene, and perhaps other hydrocarbons, finally yielding viscid oils, with a small residue of carbonaceous matter. When the distillation is performed on the large scale in cast iron retorts, the gases evolved in the first half of the distillation contain, besides the constituents of the air, 15 per cent. carbonic anhydride, 11·5 carbonic oxide, 5·9 ethylene and tetrylene; at a higher temperature, the oxygen disappears, the proportion of carbonic anhydride increases, and lastly a small quantity of marsh-gas is formed. The first portion of the liquid distillate is a yellow, mobile, strong-smelling liquid, known in commerce as *essence of rosin* (*vive essence, Harzessenz*); it yields by fractional distillation, first colophonone (*q. v.*), and afterwards an optically indifferent camphene (i. 724), boiling at 160° C., having the odour and other properties of oil of turpentine, and perhaps identical with Deville's terebene. At a later stage of the dry distillation, a viscid fluorescent oil passes over, called *rosin-oil* or *paraffine-oil*, which, after being treated with quick-lime, corresponds in composition to the formula $C^{30}H^{40}O$. After rectification, it no longer exhibits fluorescence, and if again treated with lime, gives the formula $C^{30}H^{28}O$ (Schiel, Ann. Ch. Pharm. cxv. 96). At a red heat, colophony yields a mixture of gases burning with a very bright flame, which it has been attempted, though without much success, to use as an illuminating gas.

Colophony is extensively used in making varnishes and cements, in the caulking of ships, in the preparation of plasters and ointments, and as a reducing agent in the soldering of metals. Large quantities are consumed in the manufacture of yellow soap. A well known use of it is for covering the bows of violins, to prevent the bow from slipping over the strings without producing vibration. Of the products obtained by the dry distillation of colophony, the more volatile oil is used in place of turpentine oil, the more viscid rosin-oil for soap-making, and for lubricating cartwheels, &c. (Handw. d. Chem. i. [3] 160.)

COLORIMETER. An instrument for measuring the depth of colour in a liquid by comparison with a standard liquid of the same tint. The comparison is made either by varying the depth of the stratum of liquid under examination till it exhibits the same intensity of colour as the normal liquid, and then measuring the depth of the stratum, — or by diluting the stronger-coloured liquid with water, till equal columns of the two exhibit the same depth of colour.

COLORIN. A colouring matter obtained by Robiquet and Colin from madder, since shown to be impure alizarin.

COLOSTRUM. The milk of mammalia secreted in the first few days after parturition, before the access of milk-fever. It is distinguished from ordinary milk by containing a larger amount of solid constituents, also a larger proportion of fat, casein, and milk-sugar. (See MILK.)

COLOUR. (See LIGHT).—A table of oil painters' colours, with notices of their chemical and artistical qualities, drawn up by W. Linton, is given in *Ure's Dictionary of Arts, Manufactures, and Mines*, vol. i. p. 803; see also *Chimie des Couleurs pour la Peinture à l'Eau et à l'Huile*, par. J. Lefort. 12mo. Paris, 1855.

COLOURING MATTERS. This term is usually restricted to coloured compounds of vegetable or animal origin, sometimes more especially to such as exist ready formed in the bodies of plants and animals, or are easily formed from them by natural processes, such as oxidation or fermentation. Accordingly, it would be applied to such bodies as indigo, Indian yellow, and carmine, rather than to compounds like aniline-purple or murexide, which are formed by complicated artificial processes. This restriction of the term must not, however, be regarded as absolute, since many artificial organic coloured compounds resemble the natural colouring matters in their most essential properties, especially in those which render them available as dyes.

Colouring matters occur in all the organs of plants and animals. Many are obtained from roots, as alkanet, turmeric, madder, &c.; from the stems, as from sandal-wood, log-wood, Brazil-wood, &c.: leaves, flowers, fruits, and seeds are also rich in colouring matters. Of some insects, as the cochineal-insect, the entire substance is used as a dye; certain liquids of the animal organism, as the blood and bile, are also strongly coloured. Colouring matters rarely exist either in plants or animals in the separate state; indeed their separation is often a matter of considerable difficulty. Many do not exist ready formed in plants, but are produced from originally colourless compounds by oxidation or fermentation; in some instances, also, by the action of oxygen in presence of alkalis.

Colouring matters are for the most part either red, yellow, or blue, the last being the least numerous. Only one green colouring matter occurs in nature, namely, the chlorophyll of leaves.

Colouring matters have generally a saccharine and somewhat harsh taste; they are inodorous, some of them, as indigotin and alizarin, crystallise readily; others are of a resinous character. Many are volatile, as alizarin; but they must always be distilled with caution, as a heat of 150° C. is often sufficient to decompose them.

All colouring matters are affected by light, mostly absorbing oxygen under its influence, and becoming more or less decolorised. The green colour of chlorophyll on the contrary requires the presence of light for its development.

Many colouring matters are soluble in water, others only in alcohol, ether, or volatile oils; in some cases, the presence of an acid facilitates the solution, although the colouring matter may not actually possess basic properties, *e.g.* hæmatosin, indigotin, alizarin, purpurin; others on the contrary, as carthamin and santalin, dissolve readily in alkalis.

The tint of colouring matters is modified in various degrees, and sometimes completely destroyed, by chemical reagents. The alkalis turn the naturally red colour of litmus to blue, many vegetable blue colours to green, and the yellow of rhubarb or turmeric to brown. The alkaline compounds of alizarin are of a rich violet colour, though alizarin itself is reddish yellow. All colouring matters are decomposed by concentrated alkalis.

Many metallic oxides, *e.g.* alumina and oxide of tin, form chemical compounds with colouring matters. Such compounds are called lakes. Many salts also, especially those of aluminium, iron, and tin, act upon colouring matters so as to form compounds by means of which the colouring matter is fixed upon organic tissues; such substances are called mordants.

Porous substances, especially animal charcoal, absorb colouring matters without decomposing them; thus, if an infusion of logwood be decolorised by filtration through animal charcoal, the colouring matter may be recovered by treating the charcoal with a weak alkaline ley.

All organic colouring matters are destroyed by chlorine in presence of water, the action consisting, in most cases, of a direct oxidation of the colouring matter, by oxygen set free by the decomposition of water. Sometimes, however, the chlorine takes hydrogen from the colouring matter itself and partly replaces it.

Oxygen in the nascent state likewise acts as a decolorising agent, when derived from other sources; thus, peroxide of hydrogen quickly destroys the colour of organic bodies, and indigo is bleached by nitrous acid.

Sulphurous acid decomposes and bleaches many colouring matters, sometimes by abstracting oxygen, sometimes by uniting with the colouring matter and forming a colourless compound. It is a valuable bleaching agent in many cases, especially for silk and wool, because it destroys the colouring matter without acting on the tissue, whereas chlorine would act very injuriously upon it. Fruit stains are easily removed from linen by washing with a weak solution of sulphurous acid, or by holding the moistened cloth over burning sulphur; care must be taken, however, to wash it well afterwards, or the sulphuric acid produced in the reaction will destroy the fibre.

Many reducing agents, such as nascent hydrogen, sulphydric acid, alkaline sulphides, ferrous salts, &c., decolorise colouring matters in such a manner that the colour is restored by mere exposure to the air; thus, blue indigo is converted into white indigo by the action of these bodies, but recovers its blue colour by atmospheric oxidation. The action consists either in a direct deoxidation of the colouring matter, or in a combination of the colouring matter with hydrogen derived from the decomposition of water. Thus white indigo, C^8H^6NO, is formed from blue indigo, C^8H^5NO, by addition of 1 at. hydrogen. (*Traité de Chimie générale, par Pelouze et Frémy*, 2^{me} ed. v 492; *Ure's Dictionary of Arts, Manufactures, and Mines*, i. 806.)

COLUMBITE. See NIOBITE.

COLUMBIUM or **NIOBIUM.** A metal originally discovered in columbite from Massachusetts, and since shown to exist in the tantalite (or rather columbite) of Bodenmais in Bavaria, also in Samarskite, pyrochlore, wöhlerite, euxenite, and a variety of pitchblende from Satersdalen in Norway. It was discovered by Hatchett in 1801. Wollaston erroneously supposed it to be identical with tantalum, the metal discovered a short time afterwards by Ekeberg in Finland tantalite. This opinion was long received as correct, and columbium is even now spoken of in most Manuals of Chemistry as identical with tantalum; but the researches of H. Rose have shown that this supposed identity does not exist. In short, columbium is identical, not with tantalum, but with Rose's niobium (*q. v.*)

COMBUSTION. This term properly denotes the development of light and heat accompanying chemical combination. It is sometimes used as synonymous with *inflammation*, which, however, is better restricted to those cases of combustion in which the products are gaseous, in other words, in which flame is produced. *Ignition* is the incandescence of a body produced by extrinsic means, without change of its chemical constitution.

The earlier chemists, feeling daily the necessity of fire to human existence, and astonished at the changes which this power seemed to produce in charcoal, sulphur, the metals, and other bodies, regarded combustion as the grand and essential phenomenon of chemistry. At the beginning of the eighteenth century, Stahl, of Prussia, by applying the views of Albertus Magnus and Becher respecting combustion to the whole collection of facts discovered by himself and others, and uniting them into a connected whole, laid the foundation of the first system of chemistry. This system received the name of the "Phlogistic Theory," because Stahl assumed that all combustible bodies contain one and the same principle of combustion called *Phlogiston*, the escape of this substance from a heated combustible body being supposed to produce the phenomenon of combustion or fire, and its addition to a burnt body to restore the combustibility of that body: thus, phosphorus was regarded as a compound of phlogiston and phosphoric acid; lead of phlogiston and lead-earth or calx of lead, the substance now called oxide of lead. When a calx or earth was reduced to the metallic state by heating it with charcoal (a body rich in phlogiston), it was supposed that the burnt body took phlogiston from the charcoal, and was thus restored to the combustible state.

An obvious defect of the phlogistic theory was that it took no account of the essential part which the air plays in all ordinary cases of combustion, a fact suggested by common experience, and fully demonstrated by the discoveries of Scheele, Cavendish, and Priestley. Moreover it had long been known that many combustible bodies, the metals for example, do not lose, but gain weight when burnt; and towards the end of the eighteenth century Lavoisier showed, by experiments on combustion, made with a degree of accuracy in the determination of weights and volumes, quite unknown before his time, that whenever a body burns in the air or in oxygen gas, the oxygen enters into combination with the burning body, and the weight of the product is exactly equal to the sum of the weights of the combustible body burnt and of the oxygen consumed. It was also shown that, in the reduction of a metal from its calx (or oxide) by charcoal, the latter body takes oxygen from the calx and leaves the metal in the free state. In short, wherever the phlogistic theory supposed that phlogiston was removed from a body, Lavoisier's experiments showed that oxygen was taken up, and wherever, according to the former theory, phlogiston was supposed to be added, Lavoisier showed that oxygen was removed. This system of chemistry, called the "Antiphlogistic Theory," did not, however, meet with immediate acceptation from the majority of chemists, the advocates of the phlogistic system maintaining that the increase of weight of metals and other bodies in burning might be explained by abscribing to phlogiston a principle of levity,—in other words, a tendency to recede from the earth instead of falling towards it, as ponderable bodies do. Such an assumption, however improbable in itself, would of course suffice for its immediate purpose; that is to say, of accounting for the increase in weight of a body by loss of phlogiston; but the explanation thus afforded took no account of the oxygen, which Lavoisier had shown to be abstracted from the air and added to the burning body. Accordingly, as experiments were multiplied, and it was shown that in all cases of combustion, the weight of the product was equal to the weights of the combining bodies taken together, the phlogistic theory gradually lost its hold on the minds of chemists, and was ultimately abandoned.

At the time of Lavoisier, attention was chiefly directed to combustions taking place in the air or in oxygen gas, and to the reduction of metallic oxides by hydrogen or carbon. Chlorine also, then called *oxymuriatic acid*, was supposed to contain oxygen; bromine and iodine were not known. Accordingly it was natural that oxygen should be regarded as essentially the supporter of combustion, the bodies which burned in it being called combustibles. Afterwards, when chlorine was shown to be an elementary substance, and when bromine and iodine were discovered, and metals, &c., were found to burn in their vapours, the term supporter of combustion was extended to all substances capable of forming vapours in which others can burn; thus, when copper-foil burns in sulphur vapour, the sulphur may be called the supporter, and the copper the combustible. But since the same substance may act sometimes as a combustible, sometimes as a so-called supporter,—*e. g.* sulphur as a combustible with oxygen, as a supporter with metals,—the distinction has gradually become obsolete.

The development of heat and light in combustion was attributed, on Stahl's theory, to the escape of phlogiston. The antiphlogistic theory, by dwelling chiefly on the ponderable substance produced by the combustion, and the relation between its weight and those of the combining bodies, tended rather to divert attention from the attendant phenomena of light and heat, and, indeed, was somewhat reproached by the adherents of the older theory for not rendering a sufficient account of those phenomena. Lavoisier attributed the heat accompanying combustion to the separation of the latent heat of the oxygen gas; and attempts have been made to extend this mode of explanation to all cases of chemical combination, in which gaseous or liquid substances pass to the solid state. This, however, will not account satisfactorily for the more intense evolution of heat in combustions and other combinations: for the latent heat of gases and liquids is small in comparison with such developments of heat. Moreover, in many instances, the combination is not attended with condensation; *e. g.* in the combustion of charcoal or sulphur in oxygen gas, and of hydrogen in chlorine gas; or again, gaseous products are formed from solid bodies, great heat being at the same time evolved, as in the explosion of nitre with charcoal, &c.

Neither can the heat of combustion be generally attributed to diminution of specific heat in the resulting compound; for in most cases the atoms of simple substances retain their original specific heat when they enter into combination (see Atomic Weights, i. 472, and Heat). In other cases, on the contrary, combination is attended with an actual increase of specific heat, so that the result would be a production of cold, if heat were not developed from some other cause.

Thus, 1 lb. of hydrogen gas, of specific heat 3·293, combines, under the most violent evolution of heat, with 8 lbs. of oxygen of specific heat 0·236, producing 9 lbs. of water of specific heat 1·000, whereas calculation gives $\left(\frac{3{\cdot}293 + 8\,.\,0{\cdot}236}{9}\right) = 0{\cdot}576$ as the mean of the two specific heats. If then water had a specific heat $= 0{\cdot}576$, the quantity of sensible heat in the hydrogen and oxygen gases together would be exactly sufficient to bring the water formed to the same temperature as that of the gases themselves; but since the actual specific heat of water is 1·000, the quantity of sensible heat in the gases is not sufficient for this purpose; and if heat were not developed from some other cause during the combination of oxygen and hydrogen, the water produced would be much colder than the two gases before combination.

Berzelius, on reviewing these circumstances, justly concluded that all such explanations of the origin of fire are defective. He supposed that, in every chemical combination, there is a neutralisation of opposite electricities, and that this neutralisation produces the flame or fire, in the same way as it produces fire in the discharges of the Leyden phial and the voltaic battery, and in thunder. He admitted, however, that this hypothesis does not afford a satisfactory explanation of the union of the atoms after the discharge has taken place. (See CHEMICAL AFFINITY, i. 865.)

A more satisfactory explanation is that advanced by Sir Humphry Davy, viz. that the immediate cause of the phenomena of heat is motion, and that the laws of its communication are precisely the same as the laws of the communication of motion; that in fact, these phenomena are analogous to those of light, as expounded by the undulatory theory. On this principle we may explain the great heat produced by friction, and in explosions, such as those of oxide of chlorine, and chloride of nitrogen, cases in which heat and light are copiously displayed, at the same time that great enlargement of volume takes place, rendering the idea of the extrusion of a calorific fluid altogether inadmissible. Whenever the chemical forces which determine either composition or decomposition are energetically exercised, the phenomena of combustion, which are incandescence with a change of properties, are exhibited. In all cases, the heat and light depend on the same cause, and merely indicate the energy and rapidity of the reciprocal chemical attractions. No peculiar substance or phlogistic essence is necessary to the production of fire; but it is a general result of the actions of any bodies possessed of energetic chemical attractions or different electrical relations; and it is produced in all cases in which an intense and violent motion may be conceived to be communicated to the particles of bodies.

We now proceed to consider the circumstances which favour or retard combustion and determine the nature of flame, confining our attention chiefly to cases of combustion in the air. For the greater part of our knowledge on this subject we are indebted to the admirable researches of Sir Humphry Davy (Phil. Trans. 1817, pp. 45 and 77), which led him to the invention of the Miner's Safety-lamp. The subject may be treated under the following heads:—

1. The temperature and other conditions required to inflame different bodies.
2. The nature of flame and the relation between the light and heat which compose it.
3. The causes which modify and extinguish combustion.

The quantities of heat evolved in the combustion of different bodies will be more conveniently considered in the article HEAT (*q. v.*)

I. *Conditions of Inflammability.*

But few substances are capable of combining with *oxygen* at ordinary temperatures, and those which exhibit this capacity lose it at lower temperatures. The temperature required to bring about the combination of oxygen with any substance, the *burning point*, as it may be called, is different, not only for different substances, but even for the same substance, according as the combustion is to take place rapidly or slowly. Thus, phosphorus combines slowly with oxygen, or exhibits *slow combustion* at 25° C. (77° F.), but does not enter into rapid combustion till raised to 60° C. (140° F.) Charcoal likewise burns slowly below a red heat. Sulphur takes fire in the air at about 285° C. (550° F.) Most other elementary bodies require to be heated to redness before they take fire in the air or in oxygen gas. Several organo-metallic bodies, as zinc-methyl, cacodyl, and some of the antimonides of ethyl and methyl, take fire immediately on exposure to the air. Nitrogen cannot be made to unite with oxygen by elevation of temperature, except under peculiar circumstances; chlorine, bromine, and iodine not at all by heat, only by substitution.

Chlorine unites rapidly with hydrogen at ordinary temperatures, and under the influence of direct sunshine, produces a violent explosion. Many metals also burn when introduced into chlorine at ordinary temperatures. *Bromine* and *iodine* unite rapidly with phosphorus and with several metals, especially if in the finely divided state, at ordinary temperatures; but in a tube cooled with ice, phosphorus and iodine may be brought together without acting on each other.

Sulphur unites with many metals at a red heat, the combination being attended with vivid incandescence, *e. g.* with iron and copper.

The relative inflammability of different bodies in common air may be approximately estimated by fusing a series of globules of different sizes at the ends of thin iron wires, and lighting a number of very small flames of different substances, but all of the same size. A globule $\frac{1}{30}$ of an inch in diameter brought near an oil flame $\frac{1}{30}$ of an inch in diameter will, if cold, extinguish it at the distance of a diameter. The size of the globule required to extinguish the flame will afford a rough measure of the relative inflammability of the burning body. The combustibility of different gases may also be approximately measured by the sizes of the masses of heated bodies required to set them on fire. An iron wire $\frac{1}{40}$ of an inch thick at a cherry-red heat will inflame hydrogen, but not olefiant gas, which, however, is kindled by a wire $\frac{1}{8}$ of an inch thick at the same degree of heat. A wire $\frac{1}{500}$ of an inch thick must be heated to whiteness to inflame hydrogen, but it will kindle phosphoretted hydrogen at a low red heat. Carbonic oxide takes fire in the air by contact with an iron wire at a dull red heat; but the fire-damp of mines is not kindled by a wire $\frac{1}{40}$ of an inch thick heated even to whiteness. (Davy.)

Compression of the air does not appear to facilitate combustion, unless it takes place rapidly, and is consequently attended with considerable evolution of heat. Thénard, however, found that wood does not take fire in oxygen gas under the ordinary pressure at temperatures below 350° C., but under a pressure of 2·6 met. combustion begins at 252°. On the other hand, phosphorus in oxygen gas or common air exhibits slow combustion at a temperature which is lower in proportion as the gas or air is more rarefied; and a mixture of oxygen and phosphoretted hydrogen, which, under the ordinary atmospheric pressure, requires a temperature of 116·7° C. to inflame it, does not take fire at 118° when the density is increased to fifteen times its former amount; but if the mixture, contained in an inclined glass tube standing over mercury, be rarefied by setting the tube upright, combustion takes place at 20°. Döbereiner likewise found (J. pr. Chem. i. 114) that a mixture of equal measures of oxygen, hydrogen, and nitrogen gases contained in a detonating tube was always exploded by the electric spark, if the tube were open at the bottom, or merely closed with water; but not always when the tube was closed by a cork,—the compression appearing to offer an obstacle to the continuation of the combustion.

The combination of oxygen with inflammable gases and vapours is greatly facilitated by contact with *platinum* and certain other metals, the effect depending partly on the power possessed by the metal of condensing the gases on its surface or within its pores, if it be in the spongy or finely divided state, partly on a polarised condition of the molecules (see CONTACT-ACTION). When a clean plate or wire of platinum is immersed in a mixture of oxygen (or common air) and a combustible gas, a slow combustion takes place at first, by which the temperature of the solid body is raised,—and consequently, the process of combustion is not only sustained but actually accelerated; and at length the temperature of the solid body may be so much raised as to give rise to rapid combustion. The larger the surface of the metal, the more powerful is its action.

It was observed by Sir H. Davy that a mixture of oxygen gas or common air with hydrogen, carbonic oxide, olefiant gas, cyanogen, or vapour of hydrocyanic acid, alcohol, ether, rock-oil, or oil of turpentine, is brought into a state of slow combustion by contact with thin platinum foil or a spiral of platinum wire heated to a temperature short of redness,—that the heat thus developed brings the platinum to a state of bright ignition,—and that, with certain gases, rapid combustion at length ensues. He likewise found, as had been previously observed by Grotthus, that the mixture of oxygen and hydrogen gases heated not quite to redness in a glass tube, passed in a few minutes into the state of combination and formed water, without sensible evolution of light and heat. Erman showed that the platinum wire requires a temperature of only 50° to 51° C. in order to induce the combination of oxygen and hydrogen. E. Davy found that platinum-black (platinum in a state of division still finer than that of spongy platinum), moistened with alcohol, became incandescent in the air and induced combustion of the alcohol. Finally, Döbereiner discovered that freshly ignited spongy platinum (as it remains after ignition of ammonio-chloride of platinum) excites, even in the cold, first the slow, and then, under favourable circumstances, the rapid combustion of a mixture of hydrogen gas with oxygen or atmospheric air. It appears from the experiments of Döbereiner, Pleischl, Dulong, and Thénard, that this property is possessed (though in a less degree, so that in most cases the temperature must be raised, though never to the burning point) by other solid substances, both metallic and non-metallic, *e.g.* palladium, rhodium, iridium, osmium, gold, silver, cobalt, nickel, charcoal, pumice-stone, porcelain, glass, rock crystal, and fluor-spar.

These effects may be shown in either of the following ways:

1. Spongy platinum fastened to the end of a wire is suspended within a glass flask, which is then exhausted of air and filled with the mixture of oxygen and the combustible gas.—2. The gaseous mixture is contained in a vessel standing over mercury,

and the spongy platinum fastened to a wire is pushed up into it: or a piece of it is simply passed up by itself through the mercury into the gas. The platinum is best prepared for this purpose by forming a mixture of moistened clay and ammonio-chloride of platinum, or of sal-ammoniac and spongy platinum, into balls, and heating them gently: the balls thus prepared may be used several times.—3. The mixture of oxygen or air with the combustible gas is directed on the spongy platinum contained in a glass dish or a funnel.—4. The spongy platinum is attached to a fine platinum wire (for this purpose the platinum wire may be wound into a spiral, or a loose net may be made of it; and upon this a portion of ammonio-chloride of platinum, made into a thick paste with a small quantity of water, may be fastened, and then ignited); a stream of the combustible gas is then to be directed upon it: the gas is thus brought in contact with the platinum after first mixing with the air.—5. Fine platinum wire is wound from three to eight times in a spiral form round a thin glass rod or an iron wire, the turns of the spiral being kept very close together: it is then removed, and inserted by its lower extremity into the end of a glass tube, from which the combustible gas issues into the air;—or the lower turns of the spiral are fixed round the wick of a lamp fed with a combustible and volatile liquid, such as alcohol, ether, or a volatile oil; or again, the end of the wire is inserted into the middle of the wick or into a capillary tube into which the liquid rises. This arrangement serves for the *lamp without flame* or *glow-lamp* (i. 74). It is usual to set fire to the vapour, and let it burn till the platinum wire becomes red-hot; then, when the flame is blown out, the wire continues to glow.—6. A triangle of fine platinum foil is cemented by one of its corners into a thin glass rod, which serves for a handle, and held over the aperture (in some cases after being heated) from which the combustible gas issues into the air,—or else over a volatile liquid, such as alcohol or ether. The greater the purity of the ammonio-chloride, the more efficient is the spongy platinum prepared from it. As with platinum, so also with the other metals above named.

Effect of mechanical division.—Many finely divided substances are capable of burning at comparatively low temperatures, as shown by the following experiments:—When oxide of nickel, cobalt, or iron is reduced by hydrogen gas at a temperature of about 360° C., or not quite amounting to redness, or when oxalate of iron is heated in close vessels not quite to redness, whereby the iron is reduced, the metallic powder thus obtained burns with a glimmering light on being exposed to the air at ordinary temperatures. If the heat during the reduction be raised to redness, or if the metal reduced at a heat below redness be afterwards ignited in hydrogen gas, it will no longer exhibit spontaneous combustibility, possibly, because the metal when thus strongly heated agglomerates in denser masses: but if a quantity of alumina or glucina be mixed with the metallic oxide,—by mixing the solution with that of the salt of alumina or glucina, and precipitating by an alkali,—the metal, when reduced by hydrogen, even at a red heat (provided the heat has not been very intense), takes fire on exposure to the air, as readily as that which has been reduced at a lower temperature,—possibly, because the interposition of the earths, which are not reduced by the hydrogen, prevents the particles of metal from welding together. Copper reduced by hydrogen gas at a very moderate heat was likewise observed on one occasion to become covered, on exposure, with a film of oxide, without however taking fire. Iron reduced by hydrogen gas absorbs several times its volume of carbonic acid gas; it thereby loses its inflammability, which, however, it recovers by being again heated in hydrogen gas. This property of spontaneous inflammability may be explained in two different ways: 1. The metal reduced by hydrogen retains a portion of this gas enclosed among its particles; when exposed to the air, it induces combination between this substance and the oxygen of the air (after the manner of Döbereiner's process), and the great heat evolved in this combination causes the metal to take fire. Against this, however, it may be alleged that iron reduced from the oxalate cannot contain hydrogen gas enclosed amongst its particles (it may, however, contain carbonic oxide); and even when the metal is thrown into water, and the water driven off by evaporation, spontaneous combustion is still produced by contact of air.—2. The metal when exposed to the air absorbs the air mechanically, just as any porous body would do (and possibly it may absorb oxygen with peculiar avidity); and the heat developed by this mechanical absorption gives rise to the combustion. If the metal has been previously saturated with carbonic acid gas, of which perhaps it absorbs a larger quantity than of oxygen, it does not become heated by contact with the air (Magnus). Wöhler likewise found that intimate mixtures of charcoal and reduced metals often possess the property of taking fire at a red heat.

The spontaneous combustion of other porous substances, such as charcoal-powder or small coal, and especially of masses of tow, cotton, or rags saturated with oil, takes place in a similar manner. The substance absorbs and condenses the air within its pores; oxidation then commences immediately and raises the temperature, which again accelerates the oxidation; and thus the process goes on with continually increasing rapidity, till at length the mass bursts into flame. The low conducting power of such a porous mass greatly facilitates the combustion, by preventing the dissipation of the heat generated. Instances are known of olive oil igniting upon sawdust; of greasy rags from butter, heaped together, taking fire within a period of twenty-four hours; of the spontaneous combustion of tape-measures, which are covered with an oil-varnish, when heaped together; and even of an oil-skin umbrella put away in a damp state. The presence of moisture greatly promotes the spontaneous ignition of porous materials, such as hay or coal-dust, the water probably supplying oxygen to the combustible matter. (See Graham's *Report on the cause of the fire in the "Amazon."* Chem. Soc. Qu. J. v. 34.)

II. *Nature of Flame.*

The fire which accompanies the process of combustion appears either as *Glow* or *Incandescence*, when the burning body does not become gaseous before combustion, or as *Flame*, when the burning body is previously converted into gas or vapour. In the former case, the heat evolved at the surface of contact of the oxygen and the combustible body, charcoal or iron for example, heats the body and causes it to glow with various degrees of brightness, according to the temperature. Feebly glowing coals emit a dull red light (*cherry-red heat* or *dull red heat*); when more strongly heated, they emit a yellowish-red light (*bright* or *full red heat*): at still higher temperatures, a yellow light (*dull* or *commencing white heat*); then a yellowish, then a greenish, and lastly a bluish-white, intensely dazzling light (*bright*, *full*, or *dazzling white heat*).

When the combustible body is in the gaseous form, either originally or in consequence of the heat required to set it on fire, the mixture of this gas with the oxygen and the products of the combustion constitutes flame, which is, in fact, gaseous matter heated to incandescence. If the combustible gas or vapour, and the oxygen or air are uniformly mixed before ignition, the combustion takes the form of an explosion, combination taking place at once throughout the whole mass of gaseous matter, which consequently appears equally luminous throughout. A similar effect takes place when a combustible substance, such as sulphur or charcoal, is intimately mixed with a nitrate, chlorate, or other solid substance which readily gives up oxygen: if the temperature of such a mixture be raised to the burning point at one spot by friction, percussion, or the contact of a hot body, the ignition of the first few particles raises the temperature of the next, and then the action is propagated in an inappreciably short space of time throughout the whole mass, producing a sudden and violent evolution of gas, occupying many thousand times the volume of the original solid mixture. The noise attending the explosion arises from the violent concussion of the surrounding air produced by the sudden expansion of the burning gases.

But when the combustible gas or vapour issues from an orifice or a wick into the air, or into an atmosphere of oxygen, the combustion takes place gradually at the surface of contact of the two gases, and a flame is produced, consisting of an inner dark and less heated space filled with the combustible gas, and a glowing envelope marking the boundary at which the combustible gas and the oxygen come in contact and unite. That such is really the structure of flame may be shown by placing a piece of phosphorus on the wick of a burning spirit lamp, the phosphorus not taking fire till it is pushed outwards. If a piece of phosphorus be placed on a wooden support in the middle of a basin filled with alcohol, and the alcohol be set on fire, the phosphorus melts, but does not take fire till the alcohol is burnt away or extinguished, or till the flame is blown on one side, or air directed upon the phosphorus by means of the blowpipe. In a similar manner, a lighted candle will go out when placed in the midst of an alcohol flame.

The *brightness* or *illuminating power of flame* depends, not only on the degree of heat, but likewise on the presence or absence of solid particles which may act as radiant points. A flame containing no such particles emits but a feeble light, even if its temperature is the highest possible—the flame of hydrogen gas, for example. But in flames which do contain solid particles, the brightness increases with the temperature to which these particles are raised. Solid particles in a flame sometimes arise from the combination of the combustible body with oxygen, *e. g.* phosphoric acid or oxide of zinc in the combustion of phosphorus or zinc; sometimes, when the burning body is an organic hydrocarbon in the gaseous state, they consist of particles of carbon in the form of soot, separated in the interior of the flame by the heat of the burning envelope. A dull flame becomes brighter by the introduction of a solid body in a finely divided state.

The following substances give a *dull flame:* hydrogen gas, carbonic oxide gas, sulphur, selenium, arsenic, alcohol—and likewise coal-gas when it is mixed with a sufficient quantity of air to cause it to burn without deposition of soot: phosphorus also burns with a dull flame in chlorine gas, because the chloride of phosphorus, which is the product of the combustion, remains in the gaseous state (H. Davy). When a spiral of platinum wire or a piece of asbestos is held in either of these flames, or some powdered oxide of zinc thrown into it, the solid matter immediately becomes white, and emits a vivid light (H. Davy). Paper soaked in solution of chloride of calcium and burnt in the flame of a spirit lamp, leaves a white network of ashes, which, when held in the feeblest alcohol flame, emits a brilliant light. (Talbot, Phil. Mag. [3] iii. 114.)

If alcohol vapour be projected from one set of tubes, and oxygen gas from another set, upon a ball of quicklime, having a stem by which it is fastened to a wire, the alcohol burning in the oxygen gas heats the ball to the most dazzling whiteness; so that the light, when reflected by a concave mirror placed behind it, is plainly visible at the distance of 68 miles. Zirconia gives a light somewhat less powerful than that of lime; that produced by magnesia is only half as strong. (Drummond, Ed. J. of Sc. 5, 319.) By the oxy-hydrogen blowpipe (i. 613) lime is rendered much more brightly luminous than by alcohol and oxygen gas. Supposing the intensity of light of a wax candle = 1, that emitted by a cylinder of lime whose circumference is one-fifth of that of the flame of the candle, is equal to 153 when it is ignited by the oxy-hydrogen flame; to 76, in the flame of ether and oxygen; to 69, in that of alcohol and oxygen; and to 19, in that of coal-gas and oxygen. Unburnt chalk, white clay, and magnesia, give much less light than burnt chalk.

A *bright flame* is produced by the following bodies:—

1. Those which in combination with oxygen form a solid compound: phosphorus, potassium, antimony, bismuth, zinc, and most other metals. (Davy.)

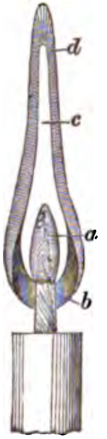
2. Compounds containing carbon, from which a portion of the carbon is separated in the form of soot, by the heat produced at the part where the combustion actually takes place, the separated carbon being first brought to a state of vivid incandescence, and subsequently burnt when it comes in contact with oxygen. This is the case with marsh-gas, olefiant gas, ether, volatile oils, fats, resins, &c. (H. Davy). The flame of alcohol may likewise be rendered bright by the presence of any substance which causes the carbon to separate from it. Thus, chlorine gas mixed with the flame of alcohol increases its luminosity, because, by combining with the hydrogen, it causes a deposition of solid carbon. Vapour of dioxide of osmium likewise gives luminosity to the flame of alcohol, by giving up osmium and separating carbon from the alcohol. To produce this effect, a piece of osmium is laid on the edge of a piece of platinum-foil, and the foil held over the alcohol flame, so that the osmium may burn, and the vapours of the oxide may mix with the vapour of alcohol (Berzelius). The flame of hydrogen or marsh-gas may be rendered bright by passing the gas through coal-tar naphtha, rock-oil, or some other volatile hydrocarbon, the vapour of which then mixes with the gas and brightens the flame by the separation of its carbon.

On the contrary, by mixing a jet of carbonaceous gas or vapour with oxygen, as in Bunsen's gas-burner, in which air is admitted just above the point where the stream of gas enters the burner, so that the gas and air become well mixed before they reach the orifice, a complete combustion of the carbon is obtained, and only gaseous products are formed, the result being a very hot smokeless flame of feeble luminosity. A similar flame is obtained by laying a sheet of wire-gauze on the top of the chimney of an Argand gas-burner, and setting fire to the gas above the gauze. The gas then becomes well mixed with air in passing up the chimney, and the carbon is completely burned as before.

The more slowly a carbonaceous substance is burned, the greater is the quantity of carbon separated from it; the brightness of the flame is, however, diminished in the same proportion, because the particles of carbon are less strongly heated. On the contrary, the quicker the combustion, the smaller is the quantity of carbon separated; but the temperature to which it is raised is so much the higher, and consequently it emits a brighter light.

The flame of highly carbonised substances, such as a wax or tallow candle, consists of four parts, as represented in fig. 129. *a*, a *dark inner cone*, surrounding the wick, and consisting of the combustible gas and vapour issuing therefrom, mixed with atmospheric nitrogen and the products of combustion, viz. water and the oxides of carbon; *b*, a *light blue zone* at the bottom of the flame, and reaching a little way up the inner cone. In this part, the combustible matter of the inner cone comes in contact with the oxygen of the air not yet rarefied by the heat, and is completely burned just as in the inner blowpipe-flame (i. 613), producing a light of the same bright blue colour. *c*, a *highly luminous cone* surrounding the dark inner cone. In this part, the supply of oxygen is not sufficient, excepting at the outer surface, for the complete combustion of the carbon, which is therefore separated in minute solid particles, and these being strongly heated by the combustion, become highly incandescent: if a cold body be introduced into the flame, these particles of carbon are deposited as soot. *d*, the *mantle*, a feebly luminous, yellowish cone surrounding the entire flame, excepting just at the bottom, and consisting of atmospheric air heated to incandescence, and mixed with the final products of the combustion. This part of the flame is often confounded with the blue zone, from which, however, it is really distinct. The best mode of observing it is to cut out a piece of cardboard of nearly the shape of the flame, and hold it at such a distance from the eye as just to hide the luminous cone.

Fig. 129.



The flame of an Argand lamp, which is supplied with air within as well as without, may be compared to the flame of an ordinary lamp or candle flattened out, and then bent into a cylinder. It contains the same parts as the conical flame, but from the form of the wick, the dark zone is necessarily very thin.

The composition of the flame of wax and tallow burning from a wick has been accurately investigated by Hilgard (Ann. Ch. Pharm. xcii. 129; Jahresb. f. Chem. 1854, p. 287). The lamp used in the experiments consisted of a shallow cylinder containing the fuel, and having in its axis a glass tube, over the upper end of which the cylindrical wick was drawn. Through this tube, which was capable of sliding up and down, a narrower tube connected at its lower end with an aspirator passed upwards into the flame. This narrow tube was attached to the outer tube by means of a caoutchouc connecter, in such a manner that no air could pass through the wide tube into the flame. By this arrangement, the gases could be collected at any required height in the flame; they then passed through a series of condensers, and finally into a glass tube in which they were sealed up for examination.

In the following table, the composition of the gases at different heights (in millimetres) above (+) and below (−) the edge of the wick is given in percentages by volume; the symbol C^2H^4 includes ethylene and the hydrocarbons polymeric with it. X denotes the weight of liquid and solid matter condensed from a litre of the flame-gas.

Composition of Wax and Tallow flames.

Beef-tallow Flame.

Height.	X.	N.	CO^2.	CO.	C^2H^4.	CH^4.	H.
+9	0·12	75·92	14·46	5·65	1·52	1·15	1·30
6	0·11	72·28	10·90	6·25	6·04	2·68	1·85
4	0·13	64·40	10·24	6·68	13·10	2·70	2·88
2	0·38	59·01	10·14	7·22	17·12	3·78	2·73
0	0·70	63·57	7·13	4·60	18·77	5·21	0·73
−3	1·49	61·72	11·73	6·27	15·13	4·00	0·15

Wax Flame.

Height.	X.	N.	CO^2.	CO.	C^2H^4.	CH^4.	H.
+10	0·12	76·62	11·70	5·16	3·70	0·85	1·97
8	0·15	73·96	11·46	5·73	5·16	0·88	2·41
6	0·18	70·34	10·53	5·50	9·21	1·70	2·71
4	0·32	64·15	9·99	5·86	14·29	2·93	2·78
2	0·48	64·09	10·07	5·62	14·89	2·63	2·73
0	1·00	65·36	10·00	5·42	14·23	2·31	2·69
− 3	1·57	63·61	10·78	5·70	14·29	3·08	2·54

Without the Nitrogen: —

Beef-tallow Flame.

Height.	X.	N.	CO^2.	CO.	C^2H^4.	CH^4.	H.
+9	. .	. .	60·06	23·46	6·29	4·79	5·40
6	. .	. .	39·31	22·54	21·79	9·68	6·68
4	. .	. .	24·78	18·75	36·81	8·08	7·58
2	. .	. .	24·73	17·62	41·78	9·21	6·66
0	. .	. .	19·58	12·68	51·51	14·28	2·00
−3	. .	. .	30·65	16·38	39·55	10·44	3·07

Wax Flame.

Height.	X.	N.	CO^2.	CO.	C^2H^4.	CH^4.	H.
+10	. .	. .	50·01	22·08	15·83	3·64	6·43
8	. .	. .	44·00	19·80	19·80	3·38	10·81
6	. .	. .	35·57	30·98	30·98	5·75	9·16
4	. .	. .	27·87	39·87	39·87	8·18	7·75
2	. .	. .	28·04	41·43	41·43	7·29	7·60
0	. .	. .	28·86	41·07	41·07	6·67	7·75
− 3	. .	. .	29·62	39·27	39·27	8·48	6·97

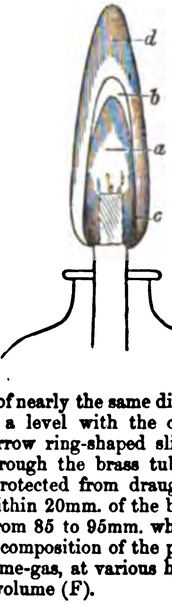
The large quantity of nitrogen in the interior of the flame arose from the circumstance, that the air entered the flame in a nearly horizontal direction, especially at the lower part. The proportion of nitrogen is a minimum at 2mm. above the edge of the wick, chiefly because the greater heat and increasing amount of decomposition in this part of the flame produce a larger amount of permanent gases. The quantity of carbonic anhydride is nearly inversely proportional to that of the hydrocarbons, C^nH^{2n}. When the nitrogen is deducted, the sums of the amounts of carbonic anhydride, ethylene, &c., and carbonic oxide are nearly constant. The total quantity of these three gases appears to alter but slightly from the bottom of the flame to a height of 7mm. or 8mm; at a greater height, it appears to increase, in consequence of the excess of the products of oxidation.

The inner cone of the flame contains the unburnt gases issuing from the wick, mixed with atmospheric nitrogen and carbonic oxide, carbonic acid, and water, produced by the combustion going on in the outer cone, but *no free oxygen*, that gas being completely converted into the products just mentioned in passing through the outer cone. The composition of the gases at different heights of the flame is determined by the natural action of the combustible gases in the inner cone and the oxidised products proceeding from the outer part.

The luminous envelope surrounding the inner cone varies in composition from without inwards, the outer portion containing a considerable quantity of free oxygen which gradually diminishes as it penetrates inwards. The thickness of the luminous envelope increases towards the upper part of the flame, because this portion contains the oxidised products ascending from below, in addition to those directly formed there, so that the proportion of combustible gases in the upper part of the flame is less the combustion is slower, and the oxygen of the air can penetrate to a greater depth; hence the luminous envelope diminishes in brightness and increases in thickness from below upwards, and near the apex it presents the appearance of a solid cone. The reducing part of the flame is at the surface of contact of the inner cone and the luminous envelope.

The flames of combustible bodies which do not undergo the decompositions above described, differ considerably in composition from those of wax or tallow. The luminous cone is often absent, more rarely the mantle: the inner cone is of course always present, and the blue zone is almost always represented by the part where the still undiluted combustible gas comes in contact, at a comparatively low temperature, with air containing its full amount of oxygen. The flame of **carbonic oxide** exhibits a distinct dark cone (consisting of unburnt gas), a dark blue zone, and a yellowish-red mantle not sharply defined from the surrounding air. The flame of **sulphur** has a blue zone at the bottom and a violet-reddish mantle, the colour with which sulphur-vapour burns when previously strongly heated. In the **alcohol-flame** (*fig.* 130) the inner cone *a* is very large, in consequence of the volatility of the combustible substance: the luminous cone *b* is small, because there is but little carbon separated; and the mantle *d* appears very much developed, because the eye is not dazzled by a bright luminous cone.

Fig. 130.



The composition of the flame of *coal-gas* has been examined by **Landolt** (Pogg. Ann. xcix. 389), by a method similar to that above described for the wax and tallow flames. The gas, properly purified from carbonic acid, oxygen, and aqueous vapour, was passed under pressure of a column of water, 17 Paris lines high, into a brass box, having at the top a circular aperture 7mm. wide, and a tube of nearly the same diameter passing tightly through the bottom, and terminating on a level with the circular opening, so that the gas was made to issue through the narrow ring-shaped slit thus formed. A tube connected with an aspirator passed up through the brass tube into the flame, as in Hilgard's experiments. The flame was protected from draughts of air by a glass cylinder suspended over it and reaching to within 20mm. of the burner; it was from 95 to 100mm. high when burning freely, and from 85 to 95mm. while gas was being drawn out of it. The following table gives the composition of the purified coal-gas (L) introduced into the burner, and that of the flame-gas, at various heights, D mm., above the ring-shaped aperture, in percentages by volume (F).

Composition of Coal-gas flame.

D . . .	0mm.		10mm.		20mm.		30mm.		40mm.		50mm.	
	L	F	L	F	L	F	L	F	L	F	L	F
Hydrogen .	39·30	20·34	41·04	12·45	44·00	9·23	44·00	4·99	41·37	3·43	41·37	2·59
Marsh-gas .	40·56	30·31	40·71	25·14	38·40	11·52	38·40	6·92	38·30	2·82	38·30	0·79
Carbonic oxide	4·95	6·59	7·64	11·71	5·73	5·71	5·73	4·68	5·56	5·26	5·56	5·45
Ethylene . .	4·04	3·80	5·10	3·59	4·13	1·86	4·13	1·55	5·00	0·90	5·00	0·60
Tetrylene .	3·15	2·75	2·18	2·65	3·14	1·34	3·14	1·00	4·34	0·77	4·34	0·58
Oxygen . .	—	0·59	—	0·65	—	0·19	—	—	—	—	—	—
Nitrogen . .	8·00	26·40	2·75	32·20	4·23	57·25	4·23	59·18	5·43	64·01	5·43	66·59
Carbonic acid .	--	1·74	0·58	1·95	0·37	4·11	0·37	4·81	—	5·62	—	7·01
Water . .	--	7·48	—	9·66	—	15·79	—	16·87	—	17·19	—	16·39

From these results, Landolt has calculated the proportions of coal-gas and air which by their mutual action form the several parts of the flame-gas. The results are somewhat discordant, according as the carbon, hydrogen, or nitrogen is taken as the basis of the calculation; but the most probable results are given in the following table, in which A denotes the volumes of atmospheric air which have mixed with 100 vols. coal-gas to produce the flame-gas at the several heights, D, indicated in the first line. 100 + A = M volumes of this unburnt gaseous mixture yield, after combustion, V volumes of flame-gas. The composition of the M volumes of unburnt gaseous mixture and of the V volumes of flame-gas produced by their combustion are given in the lower part of the table.

Composition of Coal-gas flame.

D . . .	0mm.		10mm.		20mm.		30mm.		40mm.		50mm.	
A . . .	27·08		45·43		172·76		227·73		335·30		381·66	
M . . .	127·08		145·43		272·76		327·73		435·30		481·66	
V . . .	111·41		120·09		245·96		311·37		422·59		461·23	
	M	V	M	V	M	V	M	V	M	V	M	V
Hydrogen . .	39·30	22·66	41·04	14·95	44·00	5·49	44·00	15·54	41·37	14·60	41·37	11·95
Marsh-gas . .	40·56	33·77	40·71	30·20	38·40	28·34	38·40	21·55	38·80	11·92	38·30	3·64
Carbonic oxide .	4·95	7·34	7·64	14·07	5·73	14·05	5·73	14·58	5·56	22·24	5·56	25·14
Ethylene . .	4·04	4·23	5·10	4·31	4·13	4·58	4·13	4·83	5·00	3·80	5·00	2·77
Tetrylene . .	3·15	3·06	2·18	3·18	3·14	3·29	3·14	3·11	4·34	3·25	4·34	2·68
Oxygen . .	5·67	0·66	9·52	0·78	36·21	0·47	47·73	—	70·28	—	79·99	—
Nitrogen . .	29·41	29·41	38·66	38·66	140·78	140·78	184·23	184·23	270·45	270·45	307·10	307·10
Carbonic acid .	—	1·94	—	2·34	0·37	10·11	0·37	14·98	—	23·76	—	32·34
Water . .	—	8·34	—	11·60	—	38·85	—	52·55	—	72·67	—	75·61
	127·08	111·41	145·43	120·09	272·76	245·96	327·73	311·37	435·30	422·59	481·66	461·23

The sudden increase in the quantity of air mixing with the combustible gas between the heights of 10 and 20mm., is attributed by Landolt to the effect of the glass cylinder. The proportion of carbonic acid does not increase towards the upper part of the flame so rapidly as might be expected, probably on account of the reduction of that gas to carbonic oxide by the the ignited carbon in the flame; hence also the sudden increase in the proportion of carbonic oxide between the heights of 30 and 40mm. The quantities of the several combustible gases in the flame diminish from below upwards, at rates proportional to their combustibility. From 0 to 20mm. the decrease of the hydrogen is the most rapid; the increase in the proportion of this gas in the flame above the height of 20mm. is probably due to the reducing action of the ignited carbon in the aqueous vapour. The marsh-gas diminishes more slowly, and the heavy hydrocarbons still more slowly, the latter indeed remaining nearly unaltered in the flame up to 40mm., and burning only in the higher part.

The *brightest light* was found to be given out by the part of the flame a little above the top of the dark cone. In a gas-flame 100mm. high, in which the dark cone reached to about 65mm., the highest part was at 70mm., and supposing the brightness of this part = 100, that of the other parts of the flame was found to be as follows:

	mm.	mm.	mm.	mm.	mm.	mm.
Height above burner . .	80	70	60	50	40	30
Brightness at the edge . .	66	100	77	47	20	4
Brightness in the middle .	66	100	59	24	5	—

The *size of a flame* is greater in proportion as a larger quantity of oxygen is required to consume a given volume of the rising combustible gas, and also as the surrounding oxygen is mixed or combined to a greater extent with foreign gases; for, in that case, the combustible gas must present a larger circumference, and a greater number of points of contact to the oxygen, in order that the latter may be consumed as fast as it is supplied.

When different combustible gases are made to flow from a jet, in streams of given strength, into oxygen gas and mixtures containing it, the following effects are observed: Hydrogen gas gives a much smaller flame than olefiant gas (1 volume of hydrogen requires half a volume of oxygen, and 1 volume of olefiant gas requires 3 volumes of oxygen to burn it). Hydrogen gas mixed with nitrogen gives a still smaller flame than pure hydrogen. The flame of hydrogen gas in oxygen is smaller than that of the same gas in air; but there is this anomaly observed, that hydrogen gives a smaller flame in air than it does in chlorine or nitrous oxide gas,—although one volume of hydrogen gas requires 2·4 volumes of air and only 1 volume of chlorine or of nitrous oxide gas. This peculiarity is probably due to the different degrees of diffusibility of the gases through each other.

The *colour of the flame* depends partly on its temperature, partly on the nature of the substances contained in it.

Cold carbonic oxide gas gives a blue flame in burning; but if it has previously been heated, it gives a yellowish red flame. Hydrogen and other gases, which in burning evolve more heat than is evolved by carbonic oxide, exhibit a yellowish red flame even when set on fire in the cold. But when hydrogen gas issues from a fine jet (as in Marsh's apparatus) against a porcelain slab held close in front of it, a pale green flame is produced,—possibly in consequence of the cooling action of the porcelain. The blue flame at the lower part of the flame of a candle likewise indicates a comparatively low temperature. It is remarkable that in the glowing combustion of solid bodies the colours exhibit exactly the opposite relation (p. 1094).

The addition of boric acid, or of a metallic chloride and oil of vitriol, to alcohol, gives the flame a green colour—or, when it is more strongly heated, it turns yellow. Chloride of strontium or chloride of calcium colours the flame of alcohol red; chloride of barium, or common salt, colours it yellow; protochloride of copper gives it a bright red colour, with green and blue edges. Copper covered with oxide or sulphide (but not clean copper), held in the flame of alcohol, colours it green. The flames of other burning bodies undergo similar alterations. Chloride of strontium reddens the flame of hydrogen, marsh-gas, and olefiant gas, as also that of a candle—but only so long as the salt itself remains moist; on the flame of sulphur it has no effect. In all these cases, a portion of the added substance undoubtedly volatilises: but whether it volatilises undecomposed, so that the colour of the flame is altered merely by the presence of boracic acid, chloride of strontium, chloride of copper, &c., or whether decomposition takes place, so that boron, strontium, calcium, barium, or copper is introduced into the flame in the reduced state, is there burnt, and thereby produces a different colour—is a question not yet decided. Davy suggested the latter explanation.

Respecting the prismatic spectra produced by flames in which various salts, &c. are ignited, see ANALYSIS (i. 214), also LIGHT.

In ordinary flames, the combustible gas occupies the interior, and is surrounded by atmospheric air or oxygen gas. But the combustion may likewise be sustained by directing a stream of oxygen gas, air, &c., into a vessel filled with the combustible gas. The interior dark part of the flame then consists of oxygen gas; and this gas seems, as it were, to burn in the combustible gas. In this manner, oxygen gas (and also chlorine) may be made to burn in hydrogen; likewise oxygen gas, common air, vapour of pernitric oxide (or chlorine gas, with large deposition of soot) in olefiant gas. To produce this effect, a stoppered bell-jar standing over water is filled with olefiant gas, the stopper removed, the gas set on fire, and the oxygen tube, which is fitted into a cork, plunged into the olefiant gas, the cork serving to close the aperture. Or a quantity of chlorate of potassium, contained in a small basin suspended from the cork, may be heated till it evolves oxygen gas, and then plunged into the olefiant gas previously set on fire at the mouth of the jar: the combustion then goes on, producing a beautiful light, the colour of which may be variously modified by the addition of nitrate of sodium, strontium, or copper (Kemp, J. Pharm. xx. 413; also J. pr. Chem. iii. 44).

The flame of oxygen in hydrogen gas is green, even when both gases are quite pure: that of oxygen in marsh-gas is yellow. The first-mentioned flame is much larger than the other, because a measure of oxygen gas requires two measures of hydrogen, and only half a measure of marsh-gas (Hess, Pogg. Ann. xliv. 336; also J. pr. Chem. xiii. 516).

The flame is smaller when oxygen or nitrous oxide gas, or vapour of nitric peroxide, or chlorine gas is made to pass into hydrogen gas, than in the contrary case; according to what was said on p. 1098, the contrary might have been expected. A much smaller flame is produced when oxygen passes into olefiant gas than when it passes into hydrogen. With olefiant gas, the flame is dark within; then follows a brilliant envelope, hot enough to melt platinum; then, towards the outside, a dark yellow flame, lengthening above and containing soot, the greater part of which remains unburnt. When oxygen gas is blown into boiling sulphur, a yellow flame is produced, dark within, red on the outside and at the apex: air gives a smaller flame than oxygen, dark within, blue without, and red at the apex (Waldie, Phil. Mag. [3] xiii. 86).

The *Blow-pipe flame* is of the same character as those just mentioned, inasmuch as the air is blown into the middle of the ascending combustible vapour. The strongest heat exists at that part of the flame where the dark cone of injected air terminates in a bluish vertex, and the burning envelope which surrounds it concentrates itself upon a single point (i. 611).

III. *Causes which modify and extinguish Combustion.*

When the slow or rapid combination of a body with oxygen has once been set up by elevation of temperature, the continuance of this combination, after the supply of heat from without has been withdrawn, depends in general on the following condition: — Whether the quantity of heat, which the body in combining with oxygen evolves in a given time, is equal to that which, in the same time, is carried away by surrounding bodies; and consequently, whether the body remains at the temperature necessary for combustion; — and in particular: 1. On the difference between the temperature at which the body will combine with oxygen, rapidly or slowly, and the external temperature; 2. On the quantity of heat which it evolves in burning; 3. On the rarefaction or condensation of the oxygen gas; 4. On the greater or smaller admixture of foreign gaseous bodies not contributing towards the combustion; 5. On the presence of liquid or solid heat-conducting bodies.

1. Iron and diamond require a white heat to make them burn rapidly: hence, when they are heated in the air till they begin to burn, the combustion ceases as soon as the access of heat from without is discontinued, whereas sulphur, and other easily inflammable bodies, continue to burn.

2. Carbonic oxide gas, which is as easily inflammable as hydrogen, does not exhibit rapid combustion after it has been rarefied to about one-fourth of its ordinary density, because it evolves less heat during combustion. (H. Davy.)

3. A certain degree of rarefaction prevents the continuance of combustion; because combination, and therefore, also, development of heat, is retarded by it. Detonating gas (a mixture of two measures of hydrogen gas and one of oxygen), when rarefied to $\frac{1}{18}$ of its ordinary density, no longer explodes by the electric spark (H. Davy). Hydrogen gas, mixed with air in the right proportion, will not take fire under an external pressure of five inches (Grotthuss). Hydrogen gas issuing from a jet into the air exhibits rapid combustion under a fourfold rarefaction of the air, burning even with a larger flame than before, but is extinguished when the density is reduced to between $\frac{1}{7}$ and $\frac{1}{8}$ of its ordinary amount.

The burning vapour of alcohol, ether, or wax, is extinguished, under these circumstances, by a five or sixfold rarefaction; sulphuretted hydrogen by a sevenfold rarefaction of the air. Sulphur continues to exhibit rapid combustion, even when the air is rarefied fifteen times; phosphorus, when the density is reduced to $\frac{1}{60}$; while the easily inflammable variety of phosphoretted hydrogen gas produces a flashing light, even in the best vacuum that can be made with the air-pump. Vapour of ether, in air rarefied thirty times, still produces a feeble flame on the introduction of a red-hot iron. Slow combustion on the surface of platinum is exhibited by marsh-gas, down to a fourfold rarefaction of the air; by carbonic oxide, to sixfold; by vapour of alcohol, ether, or wax, to eightfold; by olefiant gas, to ten or elevenfold; by hydrogen gas, to thirteenfold; and by vapour of sulphur, down to twentyfold rarefaction of the air. By elevation of temperature, the limits of inflammability are still further extended; so that detonating gas rarefied eighteen times, and heated to redness, exhibits a light as if from combustion, on the passage of an electric spark. (H. Davy.)

Within certain limits, however, the rate of combustion is independent of the density of the surrounding atmosphere. Frankland found that a stearin candle burned away at the same rate on the summit of Mont Blanc and in the valley of Chamounix. The brightness of the flame is, however, greatly diminished by rarefaction of the air. A coal-gas flame, burning in artificially rarefied atmospheres, exhibited an average decrease of illuminating power amounting to about 5·1 per cent. for each diminution of 1 inch of mercurial pressure. (Proc. Roy. Soc. xi. 137.) See FLAME.

4. Foreign gaseous bodies, which contribute nothing to combustion, absorb a portion of the heat generated by the combination, and reduce the temperature below the burning point, the rapidity of their action being proportional to their quantity, mobility, and capacity for heat. Not only do bodies in general burn more rapidly in oxygen gas than in atmospheric air, which contains only one volume of oxygen to four of nitrogen; but iron and diamond, which, when once set on fire, continue to burn in oxygen gas, are immediately extinguished in atmospheric air. In air four or five times compressed — which, therefore, contains one volume of oxygen gas - candles, hydrogen gas, sulphur, charcoal, and iron, do not, in consequence of the abstraction of heat by the nitrogen, burn more rapidly than they would in uncompressed air, to which $\frac{1}{5}$ of a volume of oxygen had been added. One volume of detonating gas loses its power of taking fire by the electric spark, if there be added to it $\frac{1}{2}$ a volume of olefiant gas, $\frac{5}{8}$ of a volume of fluoride of silicium, 1 volume of marsh-gas, 2 volumes of sulphydric or hydrochloric acid gas, 8 volumes of hydrogen in excess, 9 volumes of oxygen in excess, or 11 volumes of carbonic oxide: 5 measures of aqueous vapour do not destroy the inflammability of 1 measure of detonating gas (H. Davy). According to

Humboldt and **Gay-Lussac** (Gilb. Ann. xx. 49), the inflammability of one volume of detonating gas is destroyed by the admixture of 5 volumes of oxygen, or 4·7 volumes of hydrogen gas. Marsh-gas is no longer inflammable by the electric spark, when it is mixed with 11 measures of oxygen instead of the 2 measures which it actually requires to combine with it (H. Davy). Coal gas burns continuously in a mixture of 1 measure of oxygen and 7 of nitrogen, but is extinguished when the quantity of the latter amounts to 8 measures; it burns in a mixture of 1 measure of oxygen with 3, but not with 4 measures of hydrochloric acid gas; with $2\frac{1}{3}$, but not with 3 measures of carbonic acid: with 2, but not with $2\frac{1}{2}$ measures of fluoride of silicium. The greater the density of the inactive gas, the smaller is the quantity which suffices to stop the combustion; because the combustible gas diffuses itself more readily through a heavy than through a light gas, and therefore cools down the faster (Waldie). A lighted candle is extinguished in air to which $\frac{1}{8}$ of its volume of hydrochloric acid gas, or $\frac{1}{16}$ of fluoride of silicium, has been added. When combustible bodies burn in a confined space, the relative quantity of nitrogen, &c. becomes increased, partly by consumption of oxygen, partly by formation of gaseous products of combustion, such as carbonic acid, sulphurous acid, &c.; and thus the combustion is brought to an end. In one and the same limited space, a candle goes out first, then hydrogen gas, then sulphur; while the slow combustion of phosphorus will go on as long as the smallest quantity of oxygen remains. (H. Davy.)

5. Solid burning bodies are extinguished when laid on good-conducting supports, *e. g.* glowing coals on considerable masses of metal.—A mixture of a combustible gas and oxygen will not take fire in very narrow tubes, because their sides cool down too quickly: this is the principle of the oxy-hydrogen blow-pipe (i. 616). From the same cause, the flame of a mixture of combustible gases and common air is often unable to pass through the meshes of wire-gauze: the passage of the flame takes place, however, with greater facility, the lower the temperature at which the gas takes fire, the greater the heat evolved by its combustion, the more quickly it is forced through the apertures by pressure or draught, the wider the meshes, the smaller the mass and specific heat of the metal of which the gauze is made, and the higher its temperature. Above a certain temperature, all flames pass through it. The flame of a cotton thread may be extinguished by holding over it, even at some distance, a ring of fine iron wire, or a thicker ring of glass (Davy). On this impenetrability of wire-gauze by the flame of light carburetted hydrogen gas in coal-mines, is based the *Safety-lamp* of Sir H. Davy, which consists essentially of a common oil-lamp having its flame surrounded by a cylinder of wire-gauze. When this lamp is taken to a part of the mine containing an explosive mixture of gas and air, the interior of the cylinder becomes filled with a blue flame; but this flame is not communicated to the explosive mixture outside, because it is cooled down below the burning temperature in its passage through the meshes of the gauze. (See the article SAFETY LAMP, in *Ure's Dictionary of Arts, Manufactures, and Mines*, iii. 612; also *Ronald's and Richardson's Chemical Technology*, i. [2] 511.)

The same principle is applied in many elegant contrivances now in use in chemical laboratories for burning a mixture of gas and air, so as to produce a hot smokeless flame (p. 1095), the mixture of gas and air being made to pass through a sheet of wire gauze, and set on fire at the other side, so that the flame cannot extend to the orifice whence the gas issues.

Motion of the air, produced by draught or by the bellows, accelerates combustion and increases the intensity of the heat, by continually bringing fresh portions of air in contact with the burning body. Very rapid motion of the air may however extinguish combustion, either by the cooling—if the quantity of air supplied in a given time is such that the burning body cannot in the same time consume the whole of its oxygen; or by blowing the burning vapour away from its source, so that the flame can no longer communicate with the fresh matter which issues.

Fire-extinguishing substances act either by cooling, as water does,—or by covering the burning body and thereby impeding the access of air—as when a rug or other not easily combustible body is thrown on a mass of light burning materials, or when a fire is choked with earth or ashes;—or lastly by surrounding the burning mass with an atmosphere not containing oxygen. This is the principle of *Phillips's Fire-annihilator*, in which a mixture of 20 pts. charcoal, 60 pts. saltpetre, and 5 pts. gypsum, is set on fire by means of chlorate of potash, sugar, and sulphuric acid, the heat produced by the combustion being made at the same time to convert into vapour a quantity of water contained in the apparatus. The result is the instantaneous production of a large quantity of steam, carbonic acid and other inactive gases, which can be at once directed on the burning mass. (See *Ure's Dictionary of Arts, Manufactures, and Mines*, ii. 212.)

With regard to the efficiency of steam in extinguishing fires, Mr. Graham observes in his "Report on the fire in the Amazon," already quoted (p. 1094), that "steam can only be said to be efficient in extinguishing flame, or a blaze from light objects, and is not to be relied on beyond an early stage of a fire. Upon a mass of red-hot cinders, the extinguishing effect of steam is insensible." The same is probably true with regard to carbonic acid, nitrogen, and other gases.

Method of diminishing the inflammability of light fabrics.—Much attention has lately been devoted to the problem of rendering muslin and other light fabrics non-inflammable, with the view of preventing the terrible accidents, which so frequently arise from ladies' dresses coming in contact with the flame of a candle or the fire in a grate. This object is attained by steeping the fabric in a saline solution, and then drying it in the ordinary way. The fibre is thereby surrounded with a crust of incombustible matter, which prevents it from taking fire by momentary contact with a burning body, and causes it, even if held in a flame, to burn with a slow smouldering combustion, without bursting into flame.

Almost any salt will produce this effect, but the greater number are unfit for application to articles of dress, because they injure the texture, rendering the fabric harsh, and destroying all its beauty. The salt which is found to answer most completely all the required conditions, is the *neutral tungstate of sodium.* Muslin steeped in a solution containing 20 per cent. of this salt is perfectly non-inflammable when dry, and the saline film left on its surface is smooth and of a fatty appearance like talc, and therefore does not interfere with the process of ironing, but allows the hot iron to pass smoothly over the surface. The non-fulfilment of this latter condition completely prevents the use of many other salts—such as sulphate and phosphate of ammonium, which are otherwise efficacious in destroying inflammability—for all fabrics which have to be washed and ironed.

The use of the tungstate of sodium for this purpose offers but one difficulty, viz. the formation of an acid tungstate of little solubility. This inconvenience may, however, be obviated by the addition of a small quantity of phosphoric acid or phosphate of sodium. The best way of preparing a solution of minimum strength for the purpose, is to dilute a concentrated solution of the neutral tungstate with water to 28° Twaddell, and then add 3 per cent. of phosphate of sodium. The solution is found to keep, and to answer its purpose well; it is now constantly used in Her Majesty's laundry (Versmann and Oppenheim, *Communication read before the British Association at Aberdeen*, 15th Sept. 1859; Pharm. J. Trans. [2] i. 385). The use of phosphate of ammonium for preserving light fabrics from ignition was proposed, many years ago, by Gay-Lussac.

COMENAMETHANE. Syn. with COMENAMATE OF ETHYL.

COMENAMIC ACID, $C^6H^5NO^4 + 2H^2O = \left.\begin{matrix} N.H^2.(C^6H^3O^3)'' \\ H \end{matrix}\right\}O + 2H^2O$. (How, Ed. Phil. Trans. xx. [2] 225; Ann. Ch. Pharm. lxxx. 65.)—This acid is produced by the dehydration of acid comenate of ammonium, $C^6H^3(NH^4)O^5 - H^2O = C^6H^5NO^4$. It may be prepared by heating the salt to 199° C. in a sealed tube, and precipitating the aqueous extract with hydrochloric acid; or better, by boiling aqueous comenic acid with excess of ammonia till nearly all the ammonia is expelled, collecting on a filter the grey argillaceous sediment of comenamate of ammonium and colouring matter, and dissolving it in hot water; decomposing the solution with hydrochloric acid not in excess; and purifying the precipitated dark brown scales of impure comenamic acid by repeated crystallisation from hot water, and treatment with animal charcoal free from iron. The crystals contain 2 atoms water (18·81 per cent.), and give it off at 100° C. They dissolve sparingly in cold, more freely in hot water, forming a solution which reddens litmus strongly. The acid dissolves in boiling alcohol of ordinary strength, but is nearly insoluble in boiling absolute alcohol.

The acid is decomposed by boiling with *potash*, yielding ammonia and comenate of potassium. It dissolves readily in *hydrochloric acid* and other strong mineral acids, and is precipitated therefrom by ammonia in quantity rather less than sufficient for saturation, as comenamate of ammonium.

Comenamic acid is monobasic, the normal salts being $C^6(H^4M)NO^4$. There are also several basic salts. The *ammonium-salt*, $C^6H^4(NH^4)NO^4$ forms small grains made up of delicate needles nearly insoluble in cold water; their solution reddens litmus. The *potassium-* and *sodium-salts* crystallise readily and redden litmus. The normal *barium-salt*, $Ba''(C^6H^4NO^4)^2$, obtained by mixing a solution of the crystallised ammonium-salt with chloride of barium, forms crystals with 1 at. water, which redden litmus. A *basic barium-salt*, $Ba''(C^6H^4NO^4)^2.Ba''H^2O^2 + H^2O$, is formed, by mixing chloride of barium with an ammoniacal solution of comenamate of ammonium, as a white heavy precipitate, which gives off its water (2·83 per cent.) at 100° C. The aqueous acid left in contact with carbonate of barium forms the normal or the basic salt according to the relative quantities. With *lime*, it forms two salts of similar constitution.

The ammonium-salt forms, with acetate of *lead*, a heavy insoluble precipitate.

Comenamic acid imparts to *ferric salts* a deep purple colouring, which is destroyed by mineral acids, but reproduced by water.

The crystallised ammonium-salt forms a grey precipitate with sulphate of *copper*.

The ammonium-salt super-saturated with ammonia forms, with nitrate of *silver*, a yellowish flocculent, quickly blackening precipitate; and the crystallised ammonium-salt forms a white gelatinous precipitate, which is partially decomposed by boiling water.

Comenamate of Ethyl, Comenamic ether, Comenamethane, $C^8H^9NO^4 = C^6H^4(C^2H^5)NO^4$. (How. Ed. N. Phil. J. i. 212.)—When a solution of comenamic acid in absolute alcohol is treated with dry hydrochloric acid gas, and the liquid subsequently evaporated, there remains an oil which dries up at 100° C. to a solid mass, and when dissolved in alcohol, yields a *hydrochlorate of comenamic ether*, $C^8H^9NO^4.HCl + H^2O$; and on treating this compound with oxide of silver, or with ammonia (not in excess), comenamic ether is obtained in needle-shaped crystals containing 1 at. water, which they give off at 100° C., leaving the anhydrous ether.—When the solid mass above mentioned is treated with water, comenamic acid remains undissolved, and another portion of that acid separates as a crystalline powder from the solution, which contains hydrochloric acid.

The ether is neutral; melts to a yellow liquid when heated; is not altered by ammonia in the cold; and is converted by nitric acid into oxalate of ammonia. It dissolves sparingly in cold *water*, readily in hot water and in *mineral acids*, sparingly in *absolute alcohol*.

A compound of this ether with *hydriodic acid* is obtained by heating iodide of ethyl with a solution of comenamic acid in absolute alcohol to 150° C., in sealed tubes.

COMENIC ACID. $C^6H^4O^5 = \left.\begin{matrix}(C^6H^2O^3)''\\H^2\end{matrix}\right\}O^2$, or $C^{12}H^4O^{10} = C^{12}H^2O^8.2HO$. *Parameconic acid, Anhydrous Meconic acid.*—(Robiquet, Ann. Ch. Phys. [2] li. 326; liii. 428. Liebig, Ann. Ch. Pharm. vii. 237; xxvi. 116. Stenhouse, Phil. Mag. [3] xxv. 196. H. How, Ed. Phil. Trans. xx. [2] 225. Gm. xi. 328. Gerh. ii. 182.)

Comenic acid was discovered in 1832, by Robiquet, who at first regarded it as anhydrous meconic acid; it was afterwards recognised as a distinct acid by Liebig, who first observed the formation of carbonic acid which accompanies the conversion of meconic into comenic acid. It is produced: 1. By heating meconic acid to temperatures between 120° and 220° C., the change being attended with evolution of carbonic anhydride:

$$C^7H^4O^7 = C^6H^4O^5 + CO^2.$$

2. By continued boiling of meconic acid dissolved in water or in hydrochloric acid, likewise with evolution of carbonic acid. (Robiquet.)

Preparation.—Meconic acid or its potassium or barium-salt, is boiled with a strong mineral acid; or meconate of calcium is boiled with highly concentrated hydrochloric acid (Stenhouse); or acid meconate of potassium, produced by treating crude neutral meconate of calcium with very dilute hydrochloric acid, is heated with as much strong hydrochloric acid as is required to dissolve it (How), and the solution is left to crystallise. When the mere aqueous solution of the acid is boiled, too large a quantity of brown secondary product is formed. (Robiquet, Liebig.)

To purify the product, the still reddish crystals are dissolved in a slight excess of hot concentrated potash; the solution is filtered hot to separate a small quantity of lime; the white nodules which form on cooling are washed with a small quantity of cold water, till the strongly coloured mother-liquor is removed, then boiled with excess of hydrochloric acid; and the comenic acid which separates on cooling is freed from hydrochloric acid by two or three recrystallisations from water. The still remaining tinge of red may be removed by treatment with animal charcoal (Stenhouse). Or, the impure acid is dissolved in a quantity of boiling ammonia just sufficient to dissolve it (an excess, as well as continued boiling, causes the liquid to turn brown), and filtered immediately at the boiling heat; the yellow crystals which separate from the dark filtrate when left at rest, are washed with cold water and recrystallised from hot water; their pale-yellow aqueous solution is mixed with strong hydrochloric acid; and the comenic acid, which is precipitated in the form of a white or pale yellow powder, is crystallised from boiling water.

Properties.—Comenic acid forms anhydrous prisms, laminæ, or granules, having a very faint yellowish colour, requiring more than 16 pts. of *boiling water* to dissolve them; sparingly soluble in *hydrated alcohol*, but insoluble in absolute alcohol.

Decompositions.—1. The acid, when subjected to dry distillation, behaves like meconic acid (Robiquet). When comenic (or meconic) acid is quickly heated in a retort, above the temperature of 200° to 220° C., at which pyromeconic acid would be formed, but not till complete carbonisation takes place, an acid yellowish watery liquid passes over, having a faint empyreumatic odour; and there remains a blackish grey, porous, carbonaceous mass, from whose ammoniacal solution, after filtration, hydrochloric acid throws down thick dark green flakes, which, if exposed to the air after washing with water, shrink up to a substance resembling *glance-coal* in appearance, and in its chemical relations agreeing perfectly with metagallic acid (Winckler, *Repert.* 69, 42).—2. Comenic acid suspended in water through which a stream of *chlorine gas* is passed, forms a solution of chlorocomenic acid, which crystallises out after a while, and oxalic acid, which remains in solution:

$$C^6H^4O^5 + Cl^2 = C^6H^3ClO^5 + HCl.$$

The oxalic acid and a brown colouring matter which forms during evaporation must be regarded as secondary products (How).—3. Similarly, the colourless solution of comenic acid in *bromine-water* yields bromocomenic acid which crystallises, and oxalic acid (How).—4. *Nitric acid*, even when very dilute, converts comenic acid into carbonic, hydrocyanic, and oxalic acids; and if the nitric acid is tolerably strong, and heated at the beginning of the action, the process is complete in a few minutes (How).—5. *Strong sulphuric acid* acts upon comenic acid in the same manner as on meconic acid. (Robiquet).—6. The acid dissolved in water and boiled with excess of *ammonia* till nearly all the ammonia evaporates, forms a black-red liquid, which, on cooling, deposits impure comenamate of ammonium as a grey viscid sediment. (How, p. 96.)

COMENATES.—Comenic acid is dibasic, forming neutral or normal salts, $C^6H^2M^2O^5$, and acid salts, $C^6H^3MO^5$. The neutral comenates of the alkali-metals cannot be obtained in the solid state.

Acid Comenate of Ammonium, $C^6H^3(NH^4)O^5$, is obtained in How's process for purifying comenic acid. The aqueous acid slightly supersaturated with ammonia, and evaporated in vacuo over oil of vitriol, yields four-sided prisms having a yellowish tinge; they give off 9·04 per cent. (1 at.) water at 100° C. (Stenhouse). The salt forms white square prisms having a very strong lustre; they redden litmus even when they separate on cooling from a hot solution of the acid in excess of ammonia. They do not give off anything at 177° C., but at 199°, in a sealed tube, they melt and are converted into a black mixture of charcoal and comenamate of ammonium; their aqueous solution is also converted into this salt by continued boiling with ammonia (p. 1100). They dissolve readily in boiling water, sparingly in alcohol. (How.)

Comenates of Barium. *a. Neutral.* $C^6H^2Ba''O^5 + H^2O$ (at 121° C.).—Chloride of barium mixed with a solution of the acid in excess of ammonia throws down immediately—or in very dilute solutions, after some time only—yellowish quadratic needles united in concentric groups. These crystals do not lose water at 100° C., but at 121°, they give off 19·03 per cent. water, and if then heated to redness in the air, burn away in a fiery cloud. They do not dissolve in boiling water, but when boiled with it, are converted into a basic salt, which does not give off water at 121° C., and contains 54·5 per cent. baryta. (How.)

β. Acid salt. $C^{12}H^6Ba''O^{10}$ (at 100° C.).—The free acid does not precipitate barium-salts (Stenhouse). The salt is produced when baryta is boiled with excess of the acid. Chloride of barium mixed with a cold-saturated aqueous solution of the crystallised ammonium-salt immediately forms a crystalline precipitate, and with a more dilute solution, gradually deposits transparent crystals, which give off their 20·86 per cent. (somewhat more than 3 at.) water at 100° C., and melt at a stronger heat. (How.)

Comenate of Calcium. *a. Neutral.* $C^6H^2Ca''O^5 + H^2O$ (at 121° C.)—The acid supersaturated with ammonia, precipitates from chloride of calcium, if the solutions are saturated, very short prisms, which give off 18·20 per cent. ($\frac{5}{2}$ at.) water at 121° C., and when the solutions are dilute, small shining crystals, which at 121° give off 31·37 per cent. ($5\frac{1}{2}$ at.) water. The two kinds of crystals are insoluble in water, but become basic when boiled with water.

β. Acid salt. $C^{12}H^6Ca''O^{10}$ (at 121° C.)—A mixture of chloride of calcium and a cold saturated aqueous solution of the crystalline ammonia-salt, quickly deposits transparent, shining, rhombic crystals, which give off their water slowly at 100°, but the whole, amounting to 26·15 per cent. ($\frac{7}{2}$ at.) at 121°. They dissolve readily in boiling water, and crystallise therefrom on cooling.

Comenate of Copper. $C^6H^2Cu''O^5 + H^2O$ (at 100° C.)—The dark green aqueous mixture of cupric sulphate and comenic acid (or the crystallised ammonium-salt, according to How) deposits, after a few minutes, elongated pyramids having the colour of Schweinfurt green. No acid comenate of copper appears to exist. (How.)

Comenates of Iron. *Ferric Comenate.* $Fe^2O^3.4C^6H^4O^5 + 3H^2O$, or [if $fe = \frac{2}{3}Fe$] $= fe''O.2C^{12}H^6fe''O^{10} + 5H^2O$ (at 100° C.)—Comenic acid imparts a bright red colour to ferric salts. The dark blood-red mixture of ferric sulphate with a cold-saturated solution of comenic acid or its ammoniacal salt, becomes paler by long standing, and deposits small pitch-black, shining, very hard, nearly tasteless crystals, which grate between the teeth, yield a dark brown powder, and dissolve slowly both in cold and in hot water, forming a pale red solution. (Stenhouse.)

The red mixture of aqueous comenic acid with ferric sulphate, becomes dark yellow at 65° C. (and gives off carbonic acid, according to How), by conversion of all the sesquioxide of iron into protoxide at the expense of the acid, part of which at first remains undecomposed, so that a fresh portion of ferric sulphate again produces reddening. This colour, however, disappears when the liquid is digested for twelve hours with excess of ferric sulphate, in consequence of the complete conversion of comenic acid into *another acid;* hence the no longer red liquid deposits small, pale yellow, shining crystals of a ferrous salt (probably ferrous oxalate, as the liquid contains oxalic acid, according to How), which burn away when heated, and dissolve sparingly in water; the acid of these crystals extracted by potash no longer reddens ferric salts. (Stenhouse.)

Comenate of Lead.—The acid and its ammonia-salt form with neutral acetate of lead a yellowish white granular precipitate, soluble in excess of comenic acid, but not in acetic acid. (Stenhouse.)

A lead-salt examined by Robiquet contained 54·1 per cent. oxide of lead.

Comenates of Magnesium. α. *Neutral.* $C^6H^2Mg''O^5 + \frac{3}{2}H^2O$ (at 100° C.)—Sulphate of magnesium forms with the acid saturated with ammonia, especially when the mixture is stirred, hard, closely adhering, crystalline grains, consisting of short microscopic needles. These crystals heated to 100°, slowly give off 26·50 per cent. (4 at.) water; and if then kept at 121° for four days, they give off such a quantity [nearly $\frac{3}{2}$ at.] that the residual salt contains 21·30 per cent. magnesia, and is therefore not quite anhydrous. They are not soluble in boiling water. (How.)

β. The *acid salt*, $C^{12}H^6Mg''O^{10} + H^2O$ (at 100° C.), crystallises, after a while, from a mixture of sulphate of magnesium with the cold-saturated solution of the crystalline ammonia-salt, in small rhombs, and from more dilute solutions, on evaporation, in larger crystals, which are strongly acid, give off 22·08 per cent. (3 at.) water at 116°, and dissolve readily in hot water. (How.)

Comenic acid does not precipitate *mercuric chloride.* (Stenhouse.)

Comenates of Potassium. α. *Neutral.* $C^6H^2K^2O^5$.—The aqueous acid half neutralised with potash, so as to form the mono-potassic salt, yields no precipitate, but when completely neutralised, deposits the sparingly soluble dipotassic salt. In this respect, comenic acid is opposite to meconic acid, the acid potassium-salt of which is the less soluble of the two. (Robiquet.)

β. *Acid salt.* $C^6H^3KO^5$.—The acid, dissolved in a slight excess of boiling potash-ley, yields crystals on cooling, which, after washing with cold water, crystallise from hot water in short, square, anhydrous needles, which redden litmus. (How.)

Comenates of Silver.—The *neutral salt*, $C^6H^2Ag^2O^5$, is obtained by exactly precipitating a solution of nitrate of silver with comenic acid neutralised with ammonia. The thick yellow precipitate does not detonate when heated. (Liebig.)

The *acid salt*, $C^6H^3AgO^5$, is the precipitate (white, granular, or flocculent, according to Stenhouse) which the free acid produces in solution of nitrate of silver. (Liebig.)

Comenate of Sodium.—The solution of the acid in tolerably strong boiling soda-ley yields, on cooling, nodules and prisms, which, after washing with a little cold water, crystallise from the smallest possible quantity of hot water, in acid, anhydrous, four-sided prisms, containing 17·09 per cent. soda, and therefore = $C^6H^3NaO^5$. (How.)

Comenates of Strontium.—The neutral and acid salts closely resemble the corresponding barium-salt, but are more soluble.

Substitution-derivatives of Comenic Acid.

BROMOCOMENIC ACID. $C^6H^3BrO^5$. (How, *loc. cit.*)—The colourless solution of comenic acid in a slight excess of bromine-water deposits, after a few hours, oily, colourless, shining, strongly refracting, four-sided prisms, which dissolve in water and in alcohol less easily than chlorocomenic acid; they give off their water of crystallisation at 100° C.

The acid is decomposed by *nitric acid*, yielding hydrobromic, carbonic, hydrocyanic, and oxalic acids. With *zinc* and *water* it decomposes like chlorocomenic acid.

Bromocomenic is dibasic, like comenic acid. The *acid bromocomenates of ammonium, potassium*, and *sodium* are crystallisable; the first crystallises in long needles. The neutral salts of these bases are not obtainable.

The *neutral bromocomenates of barium* and *calcium* are amorphous and insoluble; the *acid* salts are very easily soluble.

The solution of the acid in a slight excess of ammonia yields, with nitrate of silver, neutral *bromocomenate of silver* in the form of a yellow precipitate having the consistence of clay when dry; and the solution of the acid in warm water forms with nitrate of silver, flakes of the *acid salt*, $C^6H^2AgBrO^5$, which crystallises from boiling water in short shining prisms.

CHLOROCOMENIC ACID. $C^6H^3ClO^5$. (How, *loc. cit.*)—Obtained by passing chlorine through water in which pulverised comenic acid is suspended, washing the crystals which separate with cold water, and recrystallising from hot water,—or by passing chlorine into cold water saturated with acid comenate of ammonium; the liquid then acquires the colour of chlorine-water, and gradually deposits crystals of chlorocomenic acid, which increase on addition of hydrochloric acid, and may be purified as in the first process. The mother-liquor becomes continually browner, and still deposits brown crystals of the acid.

The crystals are long, colourless, shining, four-sided prisms, containing 12·47 per cent. ($\frac{3}{2}$ at.) water, which they give off at 100° C. They dissolve both in cold and in hot *water*, more readily than comenic acid; very easily in warm alcohol.

The acid melts when heated, blackens, gives off a large quantity of hydrochloric acid, and at last yields a small crystalline sublimate, probably consisting of paracomenic acid. By *nitric acid* it is quickly converted into hydrochloric, carbonic, hydrocyanic, and oxalic acids. Its aqueous solution, treated with zinc, slowly gives off hydrogen, and afterwards contains hydrochloric acid and oxide of zinc.

Chlorocomenic acid is dibasic, forming *neutral salts*, $C^6HM^2ClO^5$, and *acid salts*, $C^6H^2MClO^5$.

The *chlorocomenates* resemble the comenates, but dissolve more readily in water.

The acid chlorocomenates of ammonium, potassium, and sodium crystallise readily. The neutral salts are not obtainable.

The ammonium-salt forms with *chloride of barium* and *chloride of calcium*, bundles of needles which appear more or less quickly, according to the degree of concentration; with *sulphate of magnesium*, it gradually forms a few crystals; and with *cupric sulphate*, immediately, a crystalline precipitate. The neutral chlorocomenates of these bases appear to be all amorphous and insoluble.

The acid colours *ferric salts* deep red, like comenic acid.

Silver-salts. *a. Neutral.*—The acid dissolved in a slight excess of ammonia forms, with nitrate of silver, yellow amorphous flakes, which, after drying, resemble clay in appearance, consistence, and tenacity. The salt dried at 100° C. contains 56·85 per cent. silver, and is therefore $C^6HAg^2ClO^5$. When ignited in the air, it leaves silver, together with a small quantity of chloride of silver; when boiled with hydrochloric acid, it remains partly undecomposed. It is insoluble in boiling water, but dissolves in nitric acid, from which, if heated with the salt, it separates cyanide of silver.

b. Acid.—The warm aqueous acid added to solution of nitrate of silver throws down feathery crystals, which, after washing with cold water. separate from boiling water in short shining needles. These crystals give off 4·44 per cent. water at 100° C When ignited, they leave silver and chloride of silver.

ETHYLCOMENIC ACID. $C^8H^8O^5 = C^6H^3(C^2H^5)O^5$ (How, *loc. cit.*).—To prepare this acid, dry hydrochloric acid gas is passed through absolute alcohol in which pulverised comenic acid is suspended, till the acid dissolves, which takes place slowly; the clear liquid (which deposits nothing on addition of water) is evaporated at a temperature below 100° C.; the crystalline residue is maintained at this temperature, till it no longer smells of hydrochloric acid, and then left to crystallise by cooling from its solution in water at nearly 100°. Or, pulverised comenic acid, heated with alcohol and iodide of ethyl in a closed vessel to a temperature above 100°, forms a granular deposit consisting of an acid not yet examined, and ethylcomenic acid, in needle-shaped crystals, which may be separated and purified by recrystallisation. Similar products are obtained by heating a mixture of comenic acid, alcohol, and chloride of amyl to 150° for 12 hours.

The acid forms large square needles, which begin to evaporate at 100° C.; melt at 135° into a clear brown-red liquid, which solidifies again in the crystalline form on cooling; and if kept for a longer time at 135°, sublime in long flat unaltered needles, having the same composition. It is very soluble in water and alcohol, and reddens litmus; the aqueous solution coagulates albumin.

The acid may be boiled for a short time without alteration, but if boiled for a longer time, it yields free comenic acid. With aqueous solutions of the fixed alkalis, even in the cold, it very quickly forms salts, and yields free alcohol.

When ammoniacal gas is passed through a solution of the acid in absolute alcohol, the *ammonia salt* is deposited in yellow silky bundles of needles, which give off ammonia in dry air, and almost completely in vacuo over oil of vitriol, leaving ethylcomenic acid.

The acid imparts a deep red colour to *ferric salts*. Its *silver-salt* is gelatinous, and decomposes very quickly, even in the dark.

COMPTONITE. See THOMSONITE.

CONCENTRATION. A process which has for its object to increase the amount of a dissolved substance in a liquid, relatively to the quantity of the solvent, without adding any more of the dissolved substance itself. When the solvent is volatile, this object is effected by evaporation, as when water, alcohol, or ether is expelled from a solution by heat, by exposure to the air, or in vacuo. If the dissolved substance is more volatile than the solvent, the concentration is effected by distillation, the more concentrated liquid being then found in the distillate, as in the rectification of hydrated alcohol and of volatile oils dissolved in water. In the case of aqueous liquids, concentration is sometimes effected by freezing out the water; in this manner, a strong solution of salt may be obtained from sea-water; strong spirit from vinous liquids, &c.

A similar principle is applied to the separation of silver from lead. The argentiferous lead is melted and left to cool, till about two-thirds of the mass is solidified; this consists of nearly pure lead, the portion which still remains liquid being an alloy richer in silver than the original mass. By repeating this operation several times, the alloy at last becomes sufficiently rich in silver to be treated by cupellation.

CONCHIOLIN. An organic constituent of the shells of certain molluscs, first observed by Frémy. It closely resembles keratin, or epidermose; does not yield gelatin by boiling with water, even under strong pressure; is insoluble in water, alcohol, ether, acetic acid, dilute mineral acids, and potash-ley. It contains 50 per cent. carbon, 6 hydrogen, and 16 to 16·7 nitrogen, a composition very near to that of epidermose: whether it contains sulphur does not appear to have been made out. A similar substance, but containing only 12 or 13 per cent. nitrogen, was found by Schlossberger in the byssus of acephalous molluscs.

CONCRETIONS, ANIMAL. This term is applied to all deposits in the animal body which are destitute of distinct organic structure. They are almost always of morbid character, a few only, as the brain-sand (the sabulous matter of the pineal gland), the crystals in the auditory organs of most animals, and in the vertebral column of frogs, appearing to occur in healthy animals.

Concretions are formed:—1. In the liquid secretions, as urinary, salivary, and biliary calculi, concretions in the stomach and intestines, in the lachrymal ducts, the cavity of the nose, the sebaceous glands of the skin (gouty concretions), &c.—2. In the cellular tissue of the organs, as in the brain, heart, veins, lungs, and indeed in all parts of the body. These latter are formed by the gradual transformation of other morbid products the animal matter of which is gradually absorbed, while the inorganic substance remains, and is often increased by addition of fresh deposits. All concretions of this kind have a very similar, indeed almost identical, constitution, consisting of a base sometimes predominant, sometimes subordinate, of coagulated fibrin, with deposits of phosphate and carbonate of calcium, ammonio-magnesian phosphate and carbonate of magnesium, in variable proportions. Another class of concretions allied to those last mentioned, are the so-called asteromatose deposits in the coatings of the arteries, especially of the aorta. They are sometimes, but not always, associated with calcareous deposits, and form layers of yellowish-white colour, and very slight consistence. They consist mainly of crystalline deposits of cholesterin.

The essential constituents of animal concretions are.

Uric acid and its salts.
Xanthin and cystin.
Hippurates and benzoates.
Cholesterin and fat.
Bile-pigment or cholochrome.
Fibrin.
Phosphate of calcium; ammonio-magnesian phosphate; oxalate of calcium; carbonate of magnesium.

The following substances occur as cements or less essential constituents: urinary and gall-bladder mucus, albumin, blood-red, the biliary acids, animal matter of indeterminate character, and sometimes soluble salts.

The chemical analysis of animal concretions must always be preceded by an examination of their physical structure. They are very often made up of concentric layers of substances differing in chemical constitution, so that it becomes necessary to make a separate analysis of each layer.

As respects their behaviour when heated, concretions are distinguished as—1. *Perfectly combustible.*—2. *Partially combustible.*—3. *Incombustible.* Their special chemical characters are given in the following tables. (Handw. d. Chem. ii. [2] 171.)

1. *Stones which burn without residue when heated on platinum-foil.*

a. The nitric acid solution is coloured red by ammonia, after evaporation.		*b.* The nitric acid solution is *not* coloured red by ammonia, after evaporation.		The substance burns with a bright flame.		The substance has a brown colour, is friable, like ochre, and burns with an animal odour.	
α. Does not give off ammonia when treated with potash.	β. Gives off ammonia when treated with potash.	Turns yellow on evaporation; insoluble in carbonate of potassium.	Turns dark brown on evaporation; soluble in ammonia and in carbonate of ammonia, crystallising from the former solution in microscopic six-sided tables.	Has a distinct crystalline texture; dissolves with aid of heat in alcohol, and crystallises from the solution, on cooling, in nacreous laminæ. Insoluble in caustic potash.	Emits, in burning, the odour of burnt horn, and swells up. Soluble in caustic potash, precipitated from the solution by acetic acid; soluble in excess of acetic acid, and then precipitable by ferrocyanide of potassium.	Sparingly soluble in alcohol and in water; soluble, with dark brown colour, in potash, the solution exhibiting, with nitric acid, the variations of colour characteristic of cholochrome.	Soluble in alcohol. The solution has a bitter taste, and exhibits a splendid violet-red colour with sugar and sulphuric acid.
Uric Acid.	**Urate of Ammonia.**	**Xanthin.**	**Cystin.**	**Cholesterin.**	**Fibrin.**	**Cholochrome.**	**Biliary Acids.**

2. *Stones which leave a considerable residue when heated on platinum-foil.*

1. The residue melts easily before the blowpipe.		2. The residue does not melt before the blowpipe.			3. The substance gives, with nitric acid and ammonia, the reaction of uric acid, but leaves a residue when ignited.			
α. Does not effervesce with acids, either before or after ignition; soluble in hydrochloric acid; precipitable by ammonia; precipitated by oxalate of ammonia. Black-brown enamel with cobalt-solution.	β. Gives off the odour of ammonia when heated; soluble without effervescence in acetic acid, and precipitated from this solution in the crystalline form by ammonia. Dark red glass with cobalt-solution.	α. Residue white, not alkaline; in other respects exhibiting the behaviour of neutral phosphate of calcium.	β. The fresh substance not attacked by acetic acid. Soluble without effervescence in mineral acids, and precipitated by ammonia; residue alkaline; effervesces with acids.	γ. Emits a strong white light when ignited; effervesces with acids before ignition; precipitated from the neutralised solution by oxalate of ammonia.	α. Melts before the blowpipe, and colours the flame deep yellow.	β. Behaves like α, excepting that it does not colour the flame yellow. Its solution in hydrochloric acid gives a yellow precipitate with dichloride of platinum.	γ. Infusible before the blow-pipe, and behaves, after ignition, like carbonate of calcium.	δ. Infusible before the blowpipe. The residue dissolves, with slight effervescence, in dilute sulphuric acid, and is precipitated from this solution by potash or by ammonio-sodic phosphate.
Neutral Phosphate of Calcium.	**Ammonio-magnesian Phosphate.**	**Basic Phosphate of Calcium.**	**Oxalate of Calcium.**	**Carbonate of Calcium.**	**Urate of Sodium.**	**Urate of Potassium.**	**Urate of Calcium.**	**Urate of Magnesium.**

CONDENSATION. This term, in its most general sense, implies increase of density, but it is often restricted to the passage of a gas to the liquid or solid state.

CONDRODITE. See CHONDRODITE.

CONDURRITE. A mineral containing copper and arsenic, originally obtained from the Condurrow mine near Helstone, in Cornwall; since found in the Huel Druid mine, near Redruth; also in mines at Coquimbo and Copiapo, Chili. It forms amorphous, roundish, flattened nodules, with flat conchoïdal fracture, brownish-black colour, bluish-black on the outer surface, opaque, dull or with glimmering lustre; streak metallic; powder brownish-black; soft. Specific gravity, 4·2—5·2.

Condurrite has been frequently analysed, but with very variable results; in fact it appears to be a mixture resulting from the alteration of Domeykite (Cu^6As^2), and mainly consisting of a hydrated cuprous arsenite mixed with small quantities of manganese, sulphur, iron, and silica. (Kopp, Handw. d. Chem. ii. [3], 173.)

CONGLOMERATE. A geological term applied to masses of rounded fragments of older rocks held together by a cement; if, on the other hand, the fragments are for the most part sharp-edged, the mass is called breccia. Conglomerates are distinguished as quartzose, calcareous, dolomitic, granitic, syenitic, &c., according to the nature of the component fragments: the cement may be siliceous, calcareous, or argillaceous.

ADDENDA.

ACETYLENE. C^2H^2. A gaseous hydrocarbon, which appears to have been first obtained by E. Davy (Records of gen. Sci. Nov. 1836; Gm. viii. 150), though in an impure state, by the action of water on the black substance which passes over in the preparation of potassium; but its preparation in the pure state, and indeed the establishment of its existence as a definite compound, is due to Berthelot (Institut, 1859, p. 410; 1860, p. 565; Rép. Chim. pure, ii. 222; Ann. Ch. Pharm. cxv. 116), who obtained it by passing ethylene-gas, or the vapour of ether, alcohol, aldehyde, or wood-spirit, through a red-hot tube, and by the action of red-hot copper on chloroform. Ether yields it in largest quantity, but by whichever of the preceding methods it is produced, it is always mixed with a considerable quantity of other gases, and requires to be purified by passing the gaseous mixture into an ammoniacal solution of cuprous chloride; a red precipitate is then formed which, when decomposed by hydrochloric acid, yields pure acetylene.

Berthelot has further shown that acetylene is one of the constituents of coal-gas, and that it may be formed by the direct combination of carbon and hydrogen, viz. by passing hydrogen gas over charcoal, heated to whiteness by the passage of the electric arc.

Acetylene is also produced: *a.* By the action of alcoholic potash on monobromethylene (vol. ii. 569), $C^2H^3Br - HBr = C^2H^2$ (Sawitsch, Compt. rend. lii. 157), or on bromide of monobromethylene ($C^2H^3Br^3$), bromacetylene, C^2HBr, being formed at the same time (Reboul, Ann. Ch. Pharm. cxxiv. 267).—*b.* By passing the vapour of monobromethylene into an ammoniacal solution of nitrate of silver, in which case a precipitate is formed consisting of the silver-compound of acetylene $C^2H^2Ag^2$ (more probably C^2HAg), which, when treated with dilute hydrochloric acid, yields acetylene (Miasnikoff, Ann. Ch. Pharm. cxviii. 330).—*c.* By heating monobromethylene with ethylate or amylate of sodium, the products being bromide of sodium, ethylic or amylic alcohol, and acetylene. (Sawitsch, see vol. ii. p. 569.)

$$\underset{\text{Bromethylene.}}{C^2H^3Br} + \underset{\substack{\text{Amylate of}\\\text{sodium.}}}{C^5H^{11}NaO} = NaBr + \underset{\substack{\text{Amylic}\\\text{alcohol.}}}{C^5H^{12}O} + \underset{\text{Acetylene.}}{C^2H^2}.$$

d. When a mixture of marsh-gas and carbonic oxide is passed through a red-hot tube. (Odling.)

$$CH^4 + CO = C^2H^2 + H^2O.$$

Acetylene is a colourless gas of specific gravity 0·92, having a peculiar and unpleasant odour, moderately soluble in water, not condensed by cold or pressure. It burns with a very bright and smoky flame, 1 vol. acetylene consuming 2½ vol. *oxygen*, and producing 2 vol. carbonic anhydride. When mixed with *chlorine*, it detonates almost instantly, even in diffused daylight, with separation of charcoal.

Acetylene unites with *copper* and with *silver*, forming detonating compounds, which are produced on passing the gas into the ammoniacal solutions of cuprous chloride and nitrate of silver respectively. The copper-compound is red, the silver-compound grey; both are decomposed by hydrochloric acid, with separation of acetylene. Acetylene mixed with air, and in presence of moisture, rapidly attacks metallic copper. The gas is absorbed and the copper becomes coated with a black deposit which explodes violently when heated. The formation of this substance (acetylide of copper mixed probably with cuprous oxide) is doubtless the cause of the dangerous explosions which sometimes occur in the cleaning out of copper gas-mains after long use. (Crova, Compt. rend. lv. 435; J. pr. Chem. lxxxvii. 124.)

Acetylene unites with *nascent hydrogen*, and is converted into ethylene C^2H^4. This change is brought about by subjecting the copper-compound of acetylene to the action of hydrogen evolved by the action of zinc on aqueous ammonia; the hydrogen evolved from acid liquids does not produce this reaction.

Acetylene unites, like ethylene, with *bromine*, *sulphuric acid*, and the elements of *water*, forming with bromine the compound $C^2H^2Br^2$, with sulphuric acid, acetyl-sulphuric acid $C^2H^2.H^2SO^4$, and with the elements of water, acetyl-alcohol $C^2H^2.H^2O = C^2H^4O$. (Berthelot.)

Acetyl-sulphuric acid, $C^2H^4SO^4$, is produced by brisk and long-continued agitation of acetylene with strong sulphuric acid. If the liquid be then carefully diluted, saturated with carbonate of barium, and the filtrate evaporated, acetyl-sulphate of barium is obtained in crystals. (Berthelot.)

Acetylic alcohol, $C^2H^4O = C^2H^2.H.O$, is obtained by distilling and rectifying the acid liquid just mentioned, as an easily decomposible liquid resembling acetone, but having an extremely pungent odour. It is somewhat more volatile than water, and is separated therefrom by carbonate of potassium, but apparently not by chloride of calcium. (Berthelot.)

Bromacetylene. C^2HBr. (Reboul, Compt. rend. lv. 136.)—Produced by the action of alcoholic potash on dibromide of dibromethylene:

$$C^2H^2Br^2.Br^2 - HBr - Br^2 = C^2HBr.$$

Also, together with acetylene and dibromethylene, by the action of boiling alcoholic potash on dibromide of monobromethylene.

$$\begin{array}{lcccc} C^2H^3Br.Br^2 & - & HBr & = & C^2H^2Br^2. \\ & & & & \text{Dibromethylene.} \\ C^2H^2Br^2 & - & HBr & = & C^2HBr. \\ & & & & \text{Bromacetylene.} \\ C^2HBr.Br^2 - HBr & - & Br^2 & = & C^2H^2. \\ & & & & \text{Acetylene.} \end{array}$$

It is spontaneously inflammable, liquefies under a pressure of three atmospheres, is soluble in water, and very soluble in dibromethylene, whereas acetylene is much less soluble in that liquid. This property may be rendered available for the separation of acetylene and bromacetylene.

It unites with *bromine*, forming the dibromide of bromacetylene, $C^2HBr^3 = C^2HBr.Br^2$. When passed into ammoniacal solution of cuprous chloride, it yields a precipitate of cuprosacetylene, $C^4H^2(Cu^2)''$.

$$2C^2HBr + 3(Cu^2)''Cl^2 = C^4H^2(Cu^2)'' + Cu''Br^2 + 3Cu''Cl^2;$$

which, when treated with hydrochloric acid, yields a gas having the composition and most of the properties of Berthelot's acetylene, but differing somewhat in its behaviour to bromine, with which it yields the compound $C^2H^2Br^4$, and a small quantity of C^2HBr^3.

ALLYLENE. C^3H^4. This compound, homologous with acetylene, is produced, in like manner, by the action of ethylate of sodium on monobromotritylene, C^3H^5Br. The materials are made to react in a sealed flask, and on opening the well-cooled vessel, a large quantity of gas escapes, which, when passed into an ammoniacal solution of cuprous chloride, produces a yellow precipitate. This precipitate decomposed by hydrochloric acid yields pure allylene, a colourless gas, having an unpleasant odour, burning with a smoky flame, and forming with *mercurous salts* a dark grey precipitate, and with *silver salts* a white precipitate which detonates when heated. The copper compound above mentioned burns with a reddish flame, and is decomposed with incandescence by bromine. (Sawitsch, Compt. rend. lii. 399; Ann. Ch. Pharm. cxix. 185.)

Allylene is also produced by passing the vapour of bromotritylene into a hot concentrated alcoholic solution of potash. The gas thus evolved forms in ammoniacal silver-solution, a precipitate consisting of a dark yellow compound, *silver-acetylene*, and a heavier white compound which is *silver-allylene*, $C^3H^4Ag^2$. The gas evolved from this compound by the action of hydrochloric acid, forms with bromine an oily liquid, which boils, with partial decomposition, between 180° and 200° C., and has the composition of a mixture of $C^3H^4Br^2$ and $C^3H^4Br^4$. (Morkownikoff, Bull. Soc. Chim. 1861, p. 90.)

CÆSIUM. *Symbol*, Cs. *Atomic weight*, 133.—A metal belonging to the same group of elements with lithium, sodium, potassium and rubidium. Its existence was detected in 1860 by Kirchhoff and Bunsen, by help of the method of *spectral analysis* which they introduced (see SPECTRUM, SPECTRAL ANALYSIS). The compounds of cæsium so closely resemble the corresponding compounds of potassium and rubidium, that no difference can be perceived between them by ordinary analytical means; but in the spectrum-apparatus a few thousandths of a milligramme can easily be detected. The most characteristic lines in the cæsium-spectrum are two blue lines Cs α and Cs β, in the neighbourhood of the strontium-line, Sr δ; they can be clearly seen, even with silicate of cæsium, and the name *Cæsium*, from *cæsius*, sky-blue, has been chosen as recalling their colour.

Cæsium has not yet been found, except in company with rubidium (see RUBIDIUM), and it occurs in even still smaller quantities than the latter element. Cæsium was first detected in the Dürkheim mineral water, ten kilogrammes of which contain not quite two milligrammes of chloride of cæsium. Kreuznach water contains less, and in the lepidolite of Rozena (which is the principal source of rubidium) only insignificant traces of it are found. (Kirchhoff and Bunsen, Pogg. Ann. cxiii. 353; Jahresber. 1861, 177.)

The most abundant source of it yet discovered appears to be the lepidolite of Hebron, in Maine, U.S. This mineral occurs there in large quantity in a coarsely crystalline granite, associated with red and green tourmaline and albite. It has a granular, and at the same time foliated crystalline structure, a pale rose to violet colour, and very closely resembles the lepidolite of Penig, in Saxony, and, like that, is also associated with the rare species, amblygonite. It contains rather more than 0·3 per cent. of cæsium, and as much rubidium as the lepidolite of Rozena. (O. D. Allen, Phil. Mag. [4] xxv. 189.)

Cæsium has also been found, in comparatively large quantity, in the mineral waters of Baden-Baden (Bunsen), Bourbonne-les-Bains, Haute-Marne (Grandeau, Ann. Ch. Phys. [3] lxvii. 177), in the *salines* of Aussee, and in the lithium-mica of Zinnwald (Schroetter, Wien Akad. Ber. xliv. 218). It exists in perceptible, but generally very small, quantities, in several other minerals, as triphyline (Blake, Sill. Am. J. [2] xxxiii. 274; Grandeau), carnallite (Erdmann), petalite (Grandeau), in the mineral water of Vichy (Grandeau), in those of Topusco and Lassinja (Schneider, Wien Akad. Ber. xlv. 483), and in the *salines* of Ebensee. (Redtenbacher, *ibid.* xliv. 153.)

The separation of cæsium from sodium and potassium depends upon the exceedingly slight solubility in water of its chloroplatinate. In order to obtain it pure, it is precipitated, together with chloride of potassium and chloride of rubidium, by means of chloride of platinum, from the mother-liquor, freed from everything except alkaline salts, obtained by the evaporation of Dürkheim water (Bunsen operated with the residue of about 40,000 kilogrammes of water); the precipitate is boiled with a *very small* quantity of water, allowed to settle, and the still hot solution decanted; when this operation has been repeated twenty times, the mixture of chloroplatinates of cæsium and rubidium which remains undissolved is reduced by heating in a stream of hydrogen, and the chlorides of those metals are extracted from the residue by boiling water. To separate the rubidium, the chlorides are transformed into carbonates, and the dry mixture of salts repeatedly exhausted with absolute alcohol, in which carbonate of cæsium is soluble, but carbonate of rubidium insoluble. As the carbonate of cæsium so obtained may still contain small quantities of potassium and rubidium, it must, for complete purification, be treated with sufficient baryta-water to render about four-fifths of it caustic, evaporated in a platinum dish, and the residue extracted with the smallest possible quantity of alcohol, which dissolves hydrate of cæsium, but leaves the carbonates of potassium and rubidium behind. When this operation has been repeated until the product, examined in the spectrum-apparatus, no longer gives the potassium and rubidium reactions, or gives them only very faintly indeed, the further treatment of it is found not to alter its equivalent weight; although the salt thus obtained is still a mixture of the chlorides of cæsium and rubidium, and not pure chloride of cæsium, as Bunsen at first supposed (*vid. infr.*).

The following process is given by Allen (*loc. cit.*) for the extraction of cæsium from the lepidolite of Hebron. Ten parts of the mineral, pulverised until it will pass through a sieve of 20 holes to the linear inch, are mixed with forty parts of coarsely powdered quicklime; a quantity of water sufficient to slake the lime is next mixed with as much hydrochloric acid as will convert from six to seven parts of the lime into chloride of calcium; the two mixtures are then united, and stirred vigorously during the slaking, thus intimately blending the mineral with suitable proportions of dry hydrate of lime and chloride of calcium. The mixture is put into Hessian crucibles, and heated to redness for six or eight hours (a shorter time would probably suffice). During the ignition, care must be taken to prevent the heat rising much above redness, as loss would then occur by volatilisation of the alkaline chlorides, and by the fusion of the mass and its consequent absorption into the crucibles. The product of this operation is detached from the crucibles, and boiled with water till all but a trace of the chlorides is removed. The solution thus obtained, containing chloride of calcium and alkaline chlorides, is evaporated till crystals begin to form; sulphuric acid is then added as long as sulphate of calcium separates, excess of acid being avoided, and the whole mass is evaporated to dryness, and strongly heated, to expel free hydrochloric acid. The residue is treated with water, the small quantity of sulphate of calcium which passes into solution is precipitated by carbonate of ammonium, the precipitate is filtered off, and the filtrate is again evaporated to dryness and ignited. In this way a mixture of the chlorides, containing also small quantities of the sulphates, of sodium, lithium, potassium, rubidium, and cæsium is obtained, from which the chlorides of the last two metals can be separated by treatment with bichloride of platinum as directed by Bunsen.

For the separation of cæsium from rubidium, Allen recommends the following process. The chlorides of the two metals are converted into sulphates, and then into carbonates, by precipitating with caustic baryta and saturating the solution with carbonic acid. From the carbonates, the acid tartrates are prepared by adding to the solution twice as much tartaric acid as is necessary to neutralise it, and these salts can then be separated from each other by fractional crystallisation: acid tartrate of rubidium requires for solution about eight times as much water as does acid tartrate of cæsium, and therefore crystallises out first, while the latter salt accumulates in the mother-liquors. The salts of the two alkalis may be thus separated from each other so completely that neither shows any trace of the presence of the other when examined with the spectroscope.

Pure metallic cæsium has not yet been obtained, but an amalgam of cæsium can be easily procured by electrolysing a solution of chloride of cæsium, using mercury as the negative pole. Cæsium-amalgam decomposes water in the cold, and when exposed to the air, gets hot and covers itself with a coating of deliquescent hydrate of cæsium. When cæsium-amalgam is connected with potassium-amalgam or with rubidium-amalgam and water, so as to form a galvanic circuit, it shows itself to be more electropositive than either of them; cæsium is therefore the most electropositive element yet known.

Bromoplatinate of Cæsium readily separates, together with the rubidium-salt, when dibromide of platinum is added to a dilute solution of the chlorides of the two metals. If potassium is present, the bromoplatinate of that metal is carried down likewise. (Allen.)

Carbonate of Cæsium, $Cs^2CO^3 + aq$.—Confusedly developed crystals, which give an anhydrous sandy powder when heated. Dissolves in 9·1 pts. absolute alcohol at 19° C., and in 5 pts. at 78·4° C.; very caustic; deliquesces in the air and gradually becomes converted into acid carbonate; dissolves in water in nearly all proportions with the aid of heat.

Acid carbonate of Cæsium, $CsHCO^3$.—Tolerably well-formed, but not measurable prismatic crystals, permanent in the air, of a glassy lustre. Reacts hardly alkaline; by ignition it is easily changed into the neutral salt.

Chloride of Cæsium, $CsCl$.—Crystallises in cubes, which deliquesce in the air like chloride of lithium, and can thereby be distinguished from chloride of potassium or of rubidium. When gently ignited, chloride of cæsium easily melts; it is somewhat volatile, and in the air easily becomes somewhat alkaline. (Bunsen.) According to Johnson and Allen pure chloride of cæsium is not deliquescent.

Chloroplatinate of Cæsium, $2CsCl.PtCl^4$.—Bright yellow sandy powder, composed of shining, transparent, microscopic, regular octohedrons. It is more difficultly soluble than the chloroplatinate of either potassium or rubidium; the following table gives the solubility in 100 pts. water of the three salts, as determined by Bunsen, the

Temperature.	Potassium-salt.	Rubidium-salt.	Cæsium-salt.
0° C. . . .	0·74	0·184	0·024
10 . . .	0·90	0·154	0·050
20 . . .	1·12	0·141	0·079
30 . . .	1·41	0·145	0·110
40 . . .	1·76	0·166	0·142
50 . . .	2·17	0·203	0·177
60 . . .	2·64	0·258	0·213
70 . . .	3·19	0·329	0·251
80 . . .	3·79	0·417	0·291
90 . . .	4·45	0·521	0·332
100 . . .	5·18	0·634	0·377

cæsium-salts having been purified by the first process, and therefore still containing a little rubidium.

Hydrate of Cæsium, CsHO + aq.—Confusedly crystallised, deliquescent, exceedingly caustic. At a red heat it does not become anhydrous; it attacks platinum, is entirely volatile when heated on a platinum wire, and is easily soluble in alcohol.

Nitrate of Cæsium, $CsNO^3$.—Contains no water of crystallisation, is isomorphous with nitrate of rubidium and not with nitrate of potassium. The crystals are hexagonal prisms combined with the hexagonal pyramid. P : P in the terminal edges = 142° 56′· in the lateral edges = 78° 58′. Rates of axes, $1 : c = 1 : 0·7135$.

$$P . \infty P . P2 . \infty P2 . 0P . \tfrac{3}{4}P.$$

The salt has a cooling saline taste, like that of saltpetre, and is soluble in ten times its weight of water at 3° C. (Bunsen.)

Picrate of Cæsium resembles the corresponding potassium-salt. It cannot be separated from picrate of rubidium by crystallisation. (Allen.)

Sulphate of Cæsium, Cs^2SO^4, forms anhydrous, ill-defined, hard crystals, grouped together in bunches, and permanent in the air. One part of the salt dissolves in 0·63 pts. of water at − 2° C. (1 pt. of sulphate of potassium dissolves in 12·5 pts. of water at the same temperature.)

Sulphate of cæsium forms double salts with sulphate of magnesium, sulphate of cobalt, &c., belonging to the type $K^2Mg''(SO^4)^2 + 6H^2O$, and is isomorphous with the corresponding potassium- and ammonium-compounds. $Cs^2Co''(SO^4)^2 + 6H^2O$, shows the following surfaces: $0P . \infty P . +P . [P\infty] . +2P\infty . \infty P2$. Sulphate of cæsium forms, with sulphate of aluminium, an alum crystallising in regular octohedrons of a glassy lustre. (Bunsen, Ann. Ch. Pharm. cxix. 111.)

Acid tartrate of Caesium, $C^4H^5CsO^6$.—Colourless, transparent, flattened prisms, which do not diminish in weight when pulverised and dried at 100°. One part of this salt dissolves in 1·02 pts. of boiling water, or in 10·32 pts. of water at 25° C. (Allen.) The *neutral tartrate* is very deliquescent. (Bunsen.)

Atomic weight of Cæsium.—The atomic weight of cæsium has been determined by the analysis of its chloride. This salt, purified from chloride of rubidium by means of chloride of platinum in the manner already described, was found by Bunsen to contain:—

	Chlorine.	Cæsium.
After the 1st purification, ...	22·334	77·666
„ 2nd „	22·334	77·666
„ 3rd „	22·316	77·684

whence he deduced 123·4 for the atomic weight of cæsium. Subsequent experiments by Johnson and Allen (Phil. Mag. [4] xxv. 196) have shown that the chloride of cæsium used for these determinations still contained chloride of rubidium, and that the atomic weight calculated from them is consequently too low. Their analyses of chloride of cæsium, prepared from the acid tartrate purified by concentrating its solution and recrystallisation, gave the following results:—

	Chlorine.	Cæsium.
I.	21·044	78·956
II.	21·031	78·969
III.	21·043	78·957
IV.	21·063	78·937

Bunsen has since published new determinations (Pogg. Ann. cxix. 1) which agree very closely with these. The chloride of cæsium used for them was prepared by the following process, from a mixture of the chlorides of cæsium and rubidium which had been previously completely freed from potassium, sodium, and lithium. The chlorides were first converted into carbonates, and then a little more tartaric acid was added to the solution than was needed to convert the cæsium into neutral tartrate and the rubidium into the acid salt (the quantity of acid requisite being deduced from a preliminary determination of the amount of chlorine in the mixed chlorides). The liquid was next evaporated to dryness, and the powdered saline mass exposed to moist air in a funnel stopped with a small filter. In this way a solution of the very deliquescent tartrate of cæsium was obtained, while the acid tartrate of rubidium remained as a solid salt in the funnel. The tartrate of cæsium was converted into chloride, precipitated with bichloride of platinum, the precipitate washed and decomposed by heating in a stream of hydrogen, and this process was repeated until the proportion of chlorine in the resulting chloride of cæsium did not alter any longer. The product so prepared gave—

	Chlorine.	Cæsium.
After the 4th purification, ...	21·057	78·943
„ 5th „	21·045	78·955
„ 6th „	21·052	78·948

Taking Ag = 107·94 and Cl = 35·46 (Stas), the mean of Johnson and Allen's experiments gives 133·03 for the atomic weight of cæsium, while the mean of Bunsen's most recent experiments gives 132·99, so that we may take Cs = 133·0 as being very near the truth.

On the spectrum of cæsium, see Johnson and Allen (Phil. Mag. [4] xxv. 199), and Bunsen (Pogg. Ann. cxix. 6).—G. C. F.

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BEING A SECOND SUPPLEMENT TO

WATTS'S DICTIONARY OF CHEMISTRY,

BRINGING THE RECORD OF

CHEMICAL DISCOVERY DOWN TO THE YEAR 1873.

By HENRY WATTS, B.A. F.R.S. F.C.S.

Assisted by eminent Scientific and Practical Chemists, Contributors to the Dictionary.

This *Supplement* brings down the record of Chemical Discovery to the end of the year 1872, including the more important discoveries published in 1873 and 1874.

The Author states in his Preface that he has again been favoured with the co-operation of two of the former Contributors to the Dictionary, namely, Professor G. C. Foster, F.R.S. and Professor Roscoe, F.R.S. and that he has been able to add to the list the names of three other gentlemen—Dr. H. E. Armstrong, Dr. H. Hewell Martin, and Mr. R. Warington—who have contributed articles of great interest and importance.

Amongst the subjects treated in this supplementary volume the following may be mentioned as deserving of special notice:—

1. *Physical and General Chemistry.* The article 'Chemical Action' contains an account of the important researches of Berthelot on the State of Salts in Solution, and of those of Favre and Valson on the Decomposition or Dissociation of Crystalline Salts in Solution. The article 'Heat' includes a description of Bunsen's Ice-calorimeter; a summary of the results obtained by Thomsen and by Marignac on the Specific Heats of Bodies in solution, and of the extensive and important researches of Thomsen and of Berthelot on the Heat developed in Chemical Action. Under 'Explosion' are given the results of recent investigations made in this country by Mr. Abel, and in France by Berthelot, and by Champion and Pellet on the conditions which determine the Explosive Force of Powder and other Detonants, on the dependence of Explosion on Vibration, and on its transmission at a distance; and under 'Gunpowder' the very important experiments lately published by Captain Noble and Mr. Abel on the Products of Combustion of Powder, and on its Explosive Force when fired under various conditions. The article 'Electricity' contains an account of Becquerel's Researches on Electro-capillary Action, of Quincke's General Theory of Electrolysis, and of Favre's Researches on the Heat developed in the Voltaic Current. 'Magnetism,' by Prof. Foster, gives the results of recent investigations on the exact measurements of the Magnetic Forces. 'Light' includes the continuation of Dr. Gladstone's researches on Refraction and Dispersion, together with many interesting results of recent investigations on Absorption, Fluorescence, and Circular Polarisation. Dr. Roscoe has kindly contributed an article on the 'Chemical Action of Light,' including a description and figure of his new Self-recording arrangement for the measurement of this action; and another on 'Spectral Analysis,' giving an account of the most recent investigations on the subject.

2. *Inorganic Chemistry.* Among the numerous articles belonging to this department of Chemistry, special mention may be made of those relating to the Chlorine-

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compounds of Phosphorus and Sulphur; to Schützenberger's researches on the Carbonyl-compounds of Platinum, and on the Phospho-platinic Compounds; to those of Cleve on the Ammoniacal Compounds of Platinum; and to Siemens's method of preparing Malleable Iron and Steel directly from the Ore.

3. *Organic Chemistry.* Belonging to this department are several articles relating to the interesting discoveries of Schorlemmer on the Paraffins and Isomeric Alcohols and Ethers derived from them; also von Meyer's researches on the Nitroparaffins, and the discovery of a new class of acids called Nitrolic Acids. The Isomerism of the Derivatives of Benzene is discussed in numerous articles, and especially in a highly important and elaborate article by Dr. Armstrong on 'Phenols' and their derivatives, including the most recent additions to our knowledge of these bodies.

4. *Physiological Chemistry.* A series of interesting articles relating to this department of Chemistry, viz. 'Digestion,' 'Gastric Juice,' 'Glycogen,' 'Muscular Tissue,' 'Proteids,' 'Respiration,' and 'Urine,' has been communicated by Dr. H. N. Martin, of Christ's College, Cambridge.

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